SCIENCE

Rock the universe

Ohio State scientists join international effort to study origin of, well, everything

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BY KEVIN MAYHOOD

THE COLUMBUS DISPATCH

Thousands of scientists around the world are watching to see whether a giant machine buried deep in the ground near the French-Swiss border will deliver as advertised and peel back the very fabric of the universe to reveal a host of secrets kept mum since the big bang.

"Depending on what they find, it could change nothing or it could change everything," said Glenn Starkman, a theoretical physicist at Case Western Reserve University in Cleveland.

Everything about the Large Hadron Collider is gargantuan. The cost ($8 billion), the size (it contains a 17-mile-long collision tunnel) and the gizmos (they are using an 80-megapixel camera).

Perhaps only its goals are larger. Scientists want to blast down to the most fundamental forms of matter and find the set of rules that everything in the universe -- down to subatomic particles -- lives by.

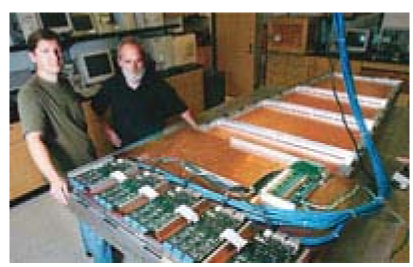
"Such understanding can open doors to knowledge and applications that we can't even conceive of right now," Ohio State University physicist Thomas Humanic wrote in an e-mail last week from Switzerland, where the collider was built.

The machine was designed to create collisions between protons as well as heavy lead ions. When matter collides, it turns into energy. And if you can make these collisions occur at nearly the speed of light, you can see subatomic particles.

On Sept. 10, the first proton streams were fired around the loop in opposite directions. There are four major detectors, each loaded with powerful magnets to guide the protons.

MARTIAL TREZZINI | KEYSTONE VIA AP

The first protons were fired Sept. 10 through the 17-mile tunnel inside the Large Hadron Collider below the ground near Geneva, Switzerland.



ADAM ALEXANDER | DISPATCH

OSU researchers Jason Gilmore and Stan Durkin show a mock-up of a section of the Compact Muon Solenoid,

In addition, heavy lead ions will be fired into fireballs that reach temperatures hotter than 1 billion degrees. Scientists predict these collisions will produce a fluid that replicates the soup created by the big bang.

Although the action will be over within a fraction of a second, the scientists who operate the collider say the first real discoveries are probably a year away.

(Or maybe longer -- the European Organization for Nuclear Research announced on Saturday that they had to shut down the machine for at least two months because of a helium leak.)

In 1991, Europeans floated the idea of building a collider. That year, the United States began to build its own, the Superconducting Super Collider, in Texas.

But Congress canceled the project in 1993, despite having spent $2 billion.

U.S. scientists quickly got involved in the European project.

"Did you think the U.S. was going to be left out of the biggest physics experiment in the world?" said Jason Gilmore, a postdoctoral researcher at Ohio State University who has been working on one of the detectors since 1996.

Nine OSU physicists and 15 graduate students and postgraduate researchers helped build and will help operate three of the four major detectors.

Here is a look at the projects on which OSU researchers are working.

ATLAS (A Toroidal LHC Apparatus)

There are more than 2,500 scientists, engineers and technicians working on ATLAS, the largest detector.

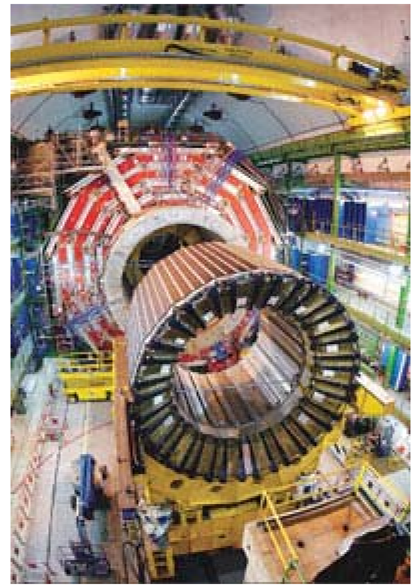
The detector is "larger than the five-story physics building at Ohio State," said K.K. Gan, who with fellow physics professors Harris P. Kagan and Richard Kass lead Ohio State's ATLAS contingent.

The OSU team built the camera that will capture subatomic particles created by the collisions. The camera, capable of taking as many as 40 million pictures per second, is positioned 5 centimeters from the proton streams.

The researchers hope to see dark matter and dark energy, invisible forces that make up more than 96 percent of the universe, and answer questions about particle mass and why the universe is made up of more matter than antimatter.

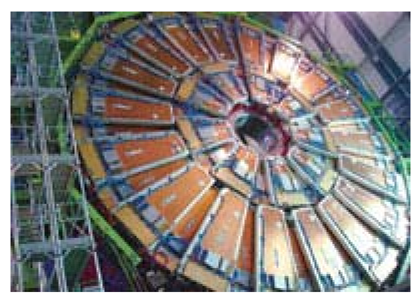
Not only is this camera fast, it can stand up to the radioactivity and

shown at right, a detector that's looking for a particle that no one has ever seen.



MARTIAL TREZZINI | KEYSTONE VIA AP

The magnet core of the Compact Muon Solenoid is one piece of the thousands that make up the collider. Scientists say big discoveries will likely unfold over the next few months.



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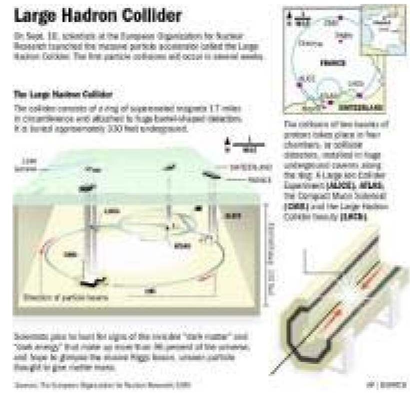

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heat that will be produced by the collisions.

"It's incredible state-of-the-art technology," Gan said.

He said he expects that the ATLAS teams will spend the next few months fine-tuning the equipment.

"We want to make sure what we see is real," Gan said, adding that at the same time, "We want to be first."

ALICE (A Large Ion Collider Experiment)

The lead ion collisions will be tracked by ALICE.

A group of researchers led by Humanic and fellow OSU physicist Michael Annan Lisa has been studying similar collisions for decades inside smaller colliders.

ALICE will let them see collisions that are 10 times more powerful using a method called two-particle femtoscopy, which will allow researchers to detect new states of matter down to a millionth of a millionth of a millimeter, Humanic said in an e-mail from Switzerland.

"This information can tell us about the properties of the lead collisions, such as helping us determine whether we have produced a Quark-Gluon plasma, the fluid state of the universe a fraction of a second after the big bang."

This "soup" should help scientists learn how matter was formed.

Though designed primarily for lead ion collisions, ALICE also will track proton collisions.

"At the moment, the OSU group is the only group that I know of in ALICE that is actively preparing to look for possible miniature black holes," Humanic said.

The OSU team built a laser guide that keeps two particle-tracking systems aligned to identify charged subatomic particles created during collisions. The team also tested thin silicon detectors that will measure the position of charged particles in the tracking systems.

To crunch all the data, scientists will use supercomputing centers worldwide. Humanic and Lisa's group will use the Ohio Supercomputing Center, which has committed 1 million computer-processing unit-hours during the next year.

That's equal to about 115 home computers running 24 hours a day for a year, said Doug Johnson, a senior systems developer at the center.

CMS (Compact Muon Solenoid)

The CMS detector will help OSU physicist Stan Durkin and colleagues find the elusive Higgs boson, matter that no one has seen but experiments say exists.

It's also called the "God particle" and is thought to give subatomic particles their mass.

Ohio State built part of the detector that is looking for muons, charged particles that are similar to electrons and positrons but are 200 times heavier.

Muons are produced during the decay of potentially new particles, including the Higgs boson. In models, the Higgs boson "signature" is produced by four muons.

Because muons are the only particles that can penetrate the iron yoke at the end of the detector, Durkin, T.Y. Ling and others built a shield of copper and electronics to track them.

The system includes computer chips that can withstand radiation, nearly 3,500 circuit boards, 200,000 channels of signal amplifiers and about 175 miles of optical cables.

"Theorists say the Higgs is a certainty," Durkin said. "I'm an experimentalist; I need to see it."

The fourth major detector is called the Large Hadron Collider Beauty, or LHCb, and will study matter and antimatter.

Kay Kinoshita, a physics professor at the University of Cincinnati, said this is an exciting time to be in the field.

At the same time, she's a bit skeptical that the collider will find everything on scientists' wish list.

"Seeing other dimensions and black holes is highly speculative," Kinoshita said. "Only part of that range is available at (the Hadron) facility."

That's what has physicists quietly planning the next collider.

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Collider glossary

Antimatter

A form of matter (something that has mass) in which the electrical charge and other properties of each particle is the reverse of matter

Big bang

The name given to the explosion that scientists say gave rise to the universe

Black hole

An extremely dense object whose gravitational field is so strong that not even light can escape

Dark energy

A form of energy thought to reside in the structure of space itself, responsible for the accelerating expansion of the universe. It appears to account for 73 percent of the mass and energy in the universe.

Dark matter

Matter that emits little or no detectable radiation. It accounts for about 23 percent of the mass and energy in the universe.

Higgs boson

A hypothetical subatomic particle that interacts with other particles and gives them mass

Ion

An atom with one or more electrons removed (positive) or added (negative)

Muon

A subatomic particle with a negative electric charge similar to an electron, but 209 times more massive

Proton

A stable subatomic particle found in the nucleus of all atoms

Subatomic particles

Particles of matter smaller than a hydrogen atom. They include protons, electrons and photons.

Sources: European Organization for Nuclear Research, *American Heritage Science Dictionary*, *Webster's New World College Dictionary*
