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Science Newsletter October 2009

Probing the smallest bits of our world

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Special points of interest:

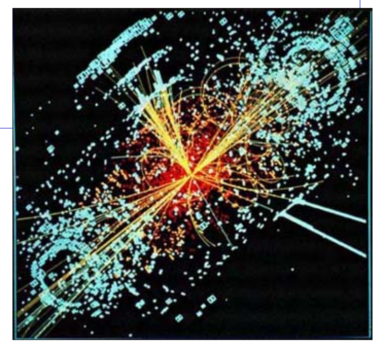
- Teeny particles..
- Triton Fun stuff
- Superfluous questions

We are always looking for **contributors** to the Science Newsletter. If you would like to write an article about a science subject you are excited about, or contribute a superfluous question, or if you would like to be on our **mailing list** for future newsletters, please e-mail us at:

info@tritonfun.com

Last September, the Large Hadron Collider (LHC), which is run by the European Center for Nuclear Research (CERN), made world news when it suffered an electrical failure which would decommission it for over a year. At 27 km (17 miles) in circumference and buried over 50 m (165 ft) underground, this machine is as big as the questions it's trying to answer: What is dark matter? What makes certain particles more massive than others? These questions are going to be investigated by the four instruments on the Large Hadron Collider: LHCb, ALICE, ATLAS, and CMS. With these instruments we hope to be able to understand the universe better.

In the classic cheesy horror movies, everyone has an evil twin hidden away from society, never known about until one day someone looks into the attic and discovers him. Well, matter also hides a secret twin: antimatter, but without the evil. Every type of particle has an anti-equivalent which differs from it in only two ways: charge, and spin direction. Additionally, when a particle and its antiparticle meet, they mutually annihilate each other in an explosion of energy. So an antielectron would appear to be just like an electron, except with a positive charge. In fact, it was this antielectron, or positron, that was discovered by Carl Anderson in 1932. He was working with a cloud chamber, an instrument which can detect rogue particles whizzing through the atmosphere, and noticed a particle that had the same mass as an electron, but was positively charged. After pursuing this discovery further, and having it independently confirmed, Anderson was credited with discovering the first antiparticle and was awarded the 1936 Nobel Prize in Physics. Now, 7 decades later, we know a menagerie of antiparticles, from antielectrons to antiprotons and even antineutrons. We also know that almost all the laws of physics do not discriminate between matter and antimatter, and that matter should be created with equal amounts of antimatter. So the outstanding question is: Where did all the antimatter go? The only antimatter we have is produced in minute quantities by energetic particle collisions for fractions of a second. This is the backdrop for the LHC beauty (LHCb) experiment. LHCb's purpose is to try and investigate processes that may have resulted in an imbalance of matter and antimatter. Specifically, LHCb will try to study the decay of the “beauty” (more commonly known as “bottom”) quark, which is only produced in high energy collisions. With LHCb, we hope to finally understand where all the antimatter went, and why matter is here to stay.



The Compact Muon Solenoid (CMS) experiment at CERN's Large Hadron Collider (LHC) will look for the Higgs boson and evidence of physics beyond the standard model. This depiction shows the decay of a Higgs particle following a collision of two protons in the CMS experiment.

Trying to recreate the Big Bang is definitely not a modest demand. But that is exactly what A Large Ion Collider Experiment (ALICE) is trying to do. By studying lead ion collisions, ALICE hopes to recreate the conditions of the first millionth of a second after the big bang. This is to solve a long-standing problem with particles called quarks. In the late 1960s with the age of the particle accelerator, the physics community was beginning to realize that protons and neutrons are not fundamental particles, but are instead composed of even smaller particles called quarks.

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Little bits of matter: *continued*

Photos/Info: CERN; MIT OpenCourseWare

Different configurations of these quarks result in different particles. An up-up-down triplet of quarks makes a proton, while a up-down-down triplet makes a neutron. However, after more was revealed in the world of these quarks, particle physicists were surprised to realize that when you add up the masses of the quarks that create a proton or a neutron separately, the total is only 1% of the actual mass of the proton. So ALICE hopes to find where the other 99% comes from. But studying quarks is a fickle business; quarks are so tiny and held together so tightly that it is impossible to pry one quark away from the others to study on its own. However, the very first instant of the big bang was hot and dense enough that quarks could not settle down into protons and neutrons, and actually filled the universe in a uniform soup (or plasma, in technical terms). It is by recreating these conditions that ALICE is trying to finally expose the quark to direct scientific investigation.

The holy grail of the LHC, however, is to find a particle called the Higgs Boson. This elusive particle is the key to answering one of the fundamental questions of how particles get their mass. The leading theory is that how particles interact with an all-permeating Higgs field determines how massive they are. Particles that interact strongly are heavier, while particles that don't interact at all are massless.

If they find this Higgs boson, physicists will be able to finally confirm the existence of the Higgs field and solve this mystery. This most important goal of the LHC will take two instruments to solve. One is A large ToroidaL ApparatuS (ATLAS) and the other is the Compact Muon Solenoid (CMS). These two both specialize in particle detection, but do so in different ways.

There are two methods of getting precise measurements of particle paths in the collisions: one is to have a strong magnetic field so that charged particles start moving around more and become more easily detected, and the other is to be big, so that particles have a larger chance of interacting with the instrument.

CMS fits the former design while ATLAS uses the latter. The reason for having two detectors is to leave no particle undetected and to provide a way to independently verify discoveries. If the Higgs boson shows up in both detectors, then physicists can be more confident they found the actual boson, instead of some experimental anomaly. Of course, in addition to the Higgs boson, they expect to find numerous other particles, such as *superparticles*, *miniature black holes*, and even the so-called *dark matter particle*. Of all the instruments, it is these two that will most likely make headlines.

So we've seen the method for probing the smallest particles is, quite literally, smashing them as hard as possible and seeing what comes out. In order to achieve the energies high enough to make these collisions, the LHC requires a highly complex and intricate system utilizing over 9000 magnets to precisely monitor and energize these particles. Operating these magnets takes a tremendous amount of energy, so they must be cooled down to 1.9 K (-456 °F) in order to make them superconducting so that they provide no resistance to electrical flow. Which brings us to the failure that brought the machine down for over a year. All it took was one imperfection in soldering that caused a short circuit and was able to generate enough heat to quench (remove superconductivity) and damage 53 magnets along with causing a leak in the liquid helium. This required a shutdown of the facility and a delay while the helium drained and the magnets were repaired.

Now, 13 months later, the magnets have all been replaced along with the installation of a quenching detection system, and the liquid helium is currently being pumped back in. After the collider has been fully cooled and tested, CERN plans to turn on the beam in late November 2009, about five weeks from now. So to those waiting to unlock the secrets the universe: just wait, it won't be long now.

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References

1. CERN website: http://public.web.cern.ch/public/
2. CERN Courier: http://cerncourier.com/cws/latest/cern

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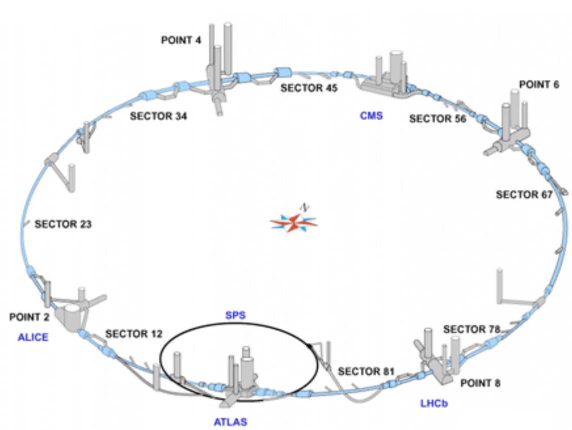

Big smasher

The Large Hadron Collider is in the eastern portion of France overlapping the border with Switzerland. Buried underground with a 17-mile circumference, its purpose is to smash particles together at high energies and break them apart so that mankind can see what the smallest bits of matter are made of. This image shows the configuration of instruments on the LHC.

TRITON FUN PRODUCTS

2009 has been declared the "International Year of Astronomy". Events and activities to further the excitement of astronomy are happening in > 100 countries sponsored by their local IYA committees. The logo for the IYA2009 is shown below. For more info on upcoming IYA2009 events, go to:

http://www.astronomy2009.org

Triton Fun is an authorized distributor of T-shirts, sweatshirts and long-sleeve tees sporting this new logo. Part of the proceeds from the sale of these shirts will go to support astronomy clubs and astronomy activities connected with IYA2009 in California.

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Superfluous Questions:

1) Which was the first chemical element to be produced artificially ?

a) Plutonium b) Lawrencium c) Technetium d) Californium

2) In the TV show *Star Trek*, Spock's mothers name was *what* ?

a) Violet b) Amanda c) Sherry d) Connie

3) Rocket J. Squirrel ("Rocky") and Bullwinkle Moose ("Bullwinkle") live in *what* state ?

a) Minnesota b) Wisconsin c) New Hampshire d) South Dakota

4) What is an Appaloosa ?

a) a type of apple b) a type of sailboat c) a type of horse d) a type of Indian tribe

—> ANSWERS in next months issue of the Science Newsletter ! <——-

** ANSWERS to September's Superfluous Questions: 1. d) Madrid 2. d) temp agency 3. a) elephant 4. a) Indiana