Welcome to Texas A&M University Research Quick Briefs.

The last few months of 2009 have been exciting ones for the $9 billion Large Hadron Collider (LHC) – a very sophisticated particle accelerator so enormous that it actually sprawls across the border between France and Switzerland just outside Geneva. The circumference of the circular tunnel that contains the facility’s instruments is no less than 17 miles!

Experimental physicists from Texas A&M University – including Teruki Kamon, Alexei Safonov, David Toback and Peter McIntyre, and theoretical physicists Dimitri Nanopoulos, Bhaskar Dutta and Richard Arnowitt – are among the many researchers worldwide who are breathlessly awaiting the first full-scale physics experiments to begin soon at the LHC, the world’s most powerful particle accelerator.

The Texas A&M physicists, like their colleagues from other institutions around the world, think the LHC may help answer some of the most long-standing questions about the nature of the physical universe. Much of the Texas A&M group’s Department of Energy-funded research in this area supports a 12-member team, headed by Dr. Kamon, Dr. Toback and Dr. Safonov, that contributed to the design and construction of one of the LHC’s two largest particle detectors - Compact Muon Solenoid (CMS). CMS is, in fact, the result of a major international collaboration, of which the U.S. component is based at the Fermi National Accelerator Laboratory (Fermilab) accelerator facility in Illinois. Since the first collisions at the LHC on November 23, the Texas A&M team has been playing a key role in analyzing the data collected by CMS.

In addition to the physicists already named, the Texas A&M team has just hired a new faculty member from Fermilab, Ricardo Eusebi. Adding Dr. Eusebi to the university’s roster of distinguished physicists is a timely coup for Texas A&M, as the LHC finally becomes available for researchers here and around the world.

This past September, the first beam of protons was sent around the enormous LHC tunnel following a year-long delay imposed by a technical problem. During the long down-time while extensive repairs were going on, scientists and technicians were making big progress on other aspects of the project, ensuring that the equipment would work much better once it was restarted. Basically the “software” for the LHC – that is, the computer-based instructions and procedures that will govern the execution of the facility’s experiments – was greatly improved during the downtime, so that the LHC is now a better instrument than ever before. That made for a very smooth restart in September.

Just a few weeks ago, on November 20, the LHC’s operators began circulating beams of protons around the underground “racetrack” again – first in just one direction, then soon after in both directions. On November 30, as Dr. Kamon reported in his online log, the new facility made history for the first time – generating a beam measured at 1.18 trillion electronvolts, or 1.18 TeV. By comparison, the most energetic beam previously generated, at Fermilab, was 0.98 TeV. The science teams at the LHC expect that the
facility will eventually be capable of generating 7 TeV – seven times more energy than Fermilab’s!

All that energy is important, according to Dr. Safonov, because increased energy makes unlikely events during the collision of particles more likely… specifically, the Texas A&M team hopes, events that might demonstrate the existence of as yet-unobserved particles such as the elusive Higgs boson, which physicists have been looking for since its existence was first proposed in the 1960s.

Dr. Toback draws an everyday analogy to what the physicists using the LHC are planning to do, using CMS and the facility’s other experimental setups… rolling dice. We usually play with a six-sided, un-loaded die that presents equal probabilities as far as which side will end up on top. Instead, what LHC scientists are working with is more like a highly “loaded” die with an unknown number of sides (we know up to 10) - one in which certain outcomes, or “sides,” are very likely, while others are very unlikely. For example, rolling a 1 – the most likely outcome - is analogous to producing electrons in a collision. Rolling a 2 stands for producing neutrinos – less likely than 1. And rolling a 10 means producing top quarks - less likely still.

The question scientists want to answer could be phrased, in terms of the analogy, as "How many sides does the die actually have?" Theories that predict the Higgs boson and supersymmetry say there are more than 20 sides… and maybe many, many more!

Researchers believe the Higgs boson probably exists – they just need to keep repeating collisions until they see it, since the probability of seeing it in any given collision is very small. Proving the existence of the Higgs boson would be a very important step in confirming the usefulness of the theoretical model that physicists have been developing for decades—what they call the Standard Model. If the Higgs boson’s existence is disproved, on the other hand, physicists will have compelling evidence that the Standard Model might not be the correct one after all. Either way, the LHC’s experiments may well solve the Higgs mystery.

Beyond revealing a new world of unknown particles -- including heavy ones that otherwise could only be seen in the split seconds following the Big Bang -- LHC experiments may explain why those particles exist and behave as they do. That will provide valuable clues regarding the origins of mass, dark matter and other mysteries of the Universe.

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