IU Physicists to get their 'glue-on'

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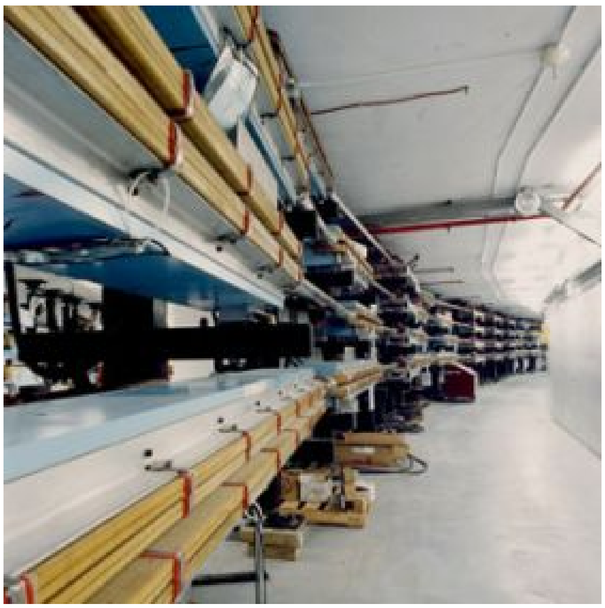

This machine accelerates a beam of electrons to an energy of 12 billion electron-volts before they pass through a diamond crystal, which produces linearly polarized photons. These photons will strike a liquid hydrogen target and interact with the quarks in the protons, possibly creating exotic glue-rich particles.

Indiana University physicists, with the backing of a National Science Foundation grant of $750,000, are preparing to study the strongest glue in the universe -- a glue so strong that it has held together the fundamental building blocks of matter since mere microseconds after the Big Bang.

Physicists call this binding element a gluon, and soon will attempt to study the fundamental force of nature through a collaborative project called "GlueX". The facilities to carry out the experiment will be located in the new Hall D at the Department of Energy's Thomas Jefferson National Accelerator Facility, known as Jefferson Lab, located in Newport News, Va., construction of which is to begin this fall.

Meanwhile, the theories behind the project's physics are being developed and integrated into software applications that will quickly and efficiently analyze the data. That development and integration, in addition to participating in the construction of a major piece of hardware, is IU's role in the experiment. The NSF's grant was issued to develop the computing processes necessary to handle the data.

"The analysis of the data will be very computationally intensive on a couple of different fronts," said Ryan Mitchell, principal investigator of IU's component in the computing project. "The size of the data and the theory behind the data will make the analysis very challenging."

The massive amounts of data will be analyzed on the TeraGrid, a network linking some of the country's fastest computers and largest data storage facilities, including IU's Big Red.

IU is no stranger to creating software applications that make data analysis easier for scientists. Similar programs at IU include the Linked Environments Atmospheric Discovery (LEAD) program, which is working towards real-time severe weather forecasts, and PolarGrid, which is analyzing the current and future states of the polar ice sheets.

The data analysis will require many computers working together at the same time. Software linking desktop computers to work on a single problem already exists, but doing the same on supercomputers and large computer clusters is a quark of a different color.

"The focus of IU's research is developing analysis algorithms and fitting techniques that are suitable for the Grid," said Matthew Shepherd, an assistant professor at Indiana University and co-principal investigator on the grant. "One question we have is how easily we can scale our problem up to something that runs on the Grid."

Details and intricacies of the theories are still being worked on, but the general idea behind gluons has been around for several decades. Gluons bind together particles called quarks to form protons and neutrons, and indirectly cause them to form the nucleus of an atom. For example, a proton is formed by three quarks bound together by gluons.

Although scientists can indirectly study gluons in protons and neutrons, they want to study "exotic mesons" as well. A meson is a particle consisting of a quark and an anti-quark bound together by gluons. An exotic meson is similar, except that the gluon binding the particles together is in an excited state.

When the two particles are stretched apart, gluon energy is collimated between them into a "flux tube." When this "string" of energy is "plucked" by adding even more energy, an exotic meson may be formed.

Exotic mesons are important to scientists because of the gluon's excited state. Studying the different energy levels of the gluon provides unique access to the behavior of the force that binds quarks together. Experimentally, exotic mesons are useful because they can be distinguished from conventional mesons with unexcited gluons.

But studying this excitable exotic won't be easy. Exotic mesons are extremely rare, difficult to create, difficult to see -- and exist for only 10^-24 seconds. To put that in perspective, it takes light 1.3 seconds to reach the moon from the earth. And in the time it takes light to travel the thickness of a single piece of paper, about 6.5 million exotic mesons could pop in and out of existence.

Plus, exotic mesons are still a highly debated topic in the world of physics. Not everyone agrees on what will be seen, but the GlueX experiment should shed light on the subject.

"Many new theoretical methods and experimental hardwares are being developed to poke gluons and see what happens," said Professor Adam Szczepaniak, director of the IU Nuclear Theory Center and consultant for the project.

Several past experiments have looked for enough exotic mesons to study and failed. Although a few experiments have caught glimpses of these rare particles, none has produced enough to study. The new equipment being built at Jefferson Lab, however, should be perfect for the job.

Exotic mesons are expected to be produced in generous amounts with the polarized photon beam operating at an ideal energy level in the new addition to Jefferson Lab. Past experiments have not had enough energy to create the exotic mesons, and future experiments could have so much energy that too many other kinds of particles are created, making exotic mesons nearly impossible to detect. Additionally, the hardware used to detect the particles will be much more sensitive than past experiments.

"Planning for the GlueX experiment has taken about a decade," said Mitchell. "The new Jefferson Lab facility is a big project, so it has taken a long time for it to get this far. We're really excited to take the next step."

Source: Indiana University