CEBAF turns on the charm

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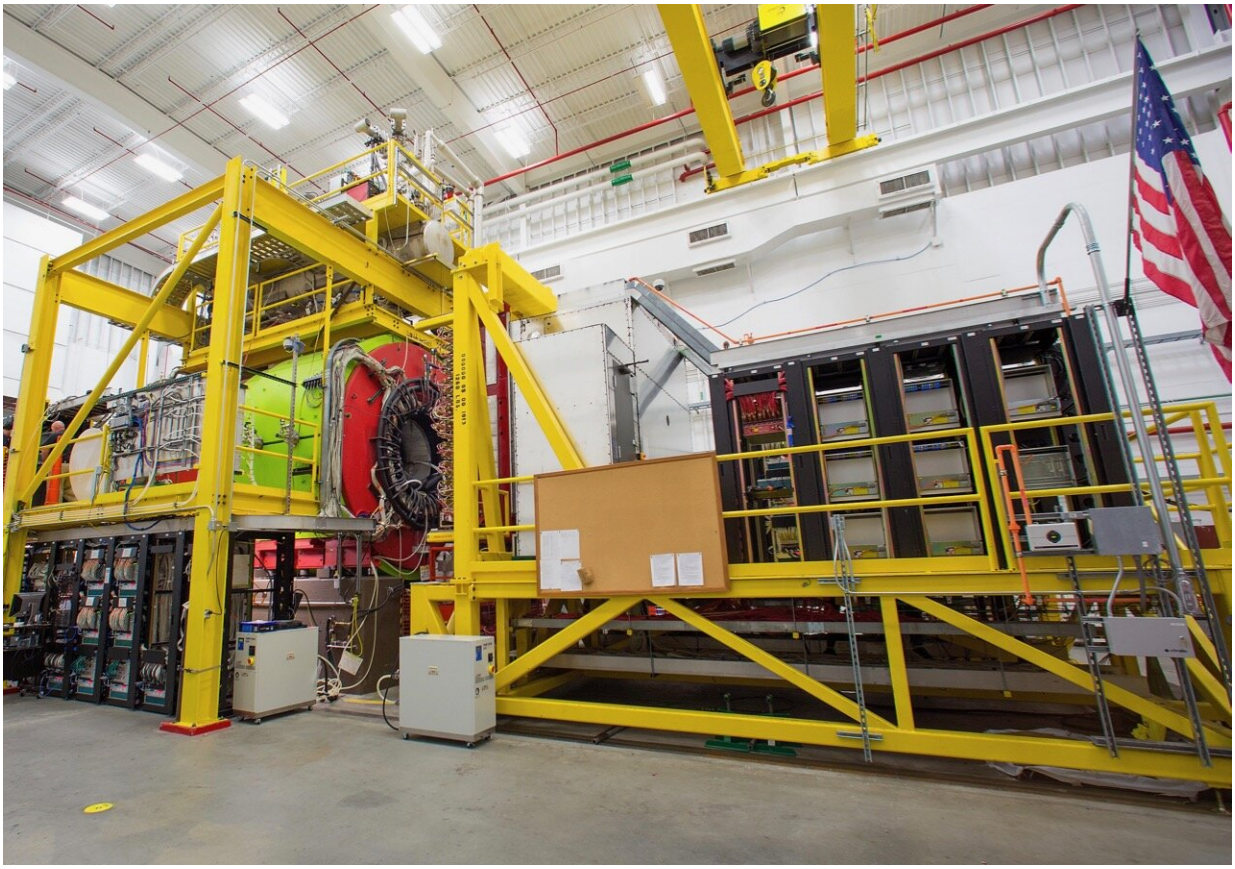

The Gluonic Excitations Experiment is installed in Jefferson Lab's Experimental Hall D. Credit: Thomas Jefferson National Accelerator Facility

The world's most advanced particle accelerator for investigating the quark structure of the atom's nucleus has just charmed physicists with a new capability. The production of charm quarks in J/ψ (J/psi) particles

by CEBAF at the Department of Energy's Thomas Jefferson National Accelerator Facility confirms that the facility has expanded the realm of precision nuclear physics research with electron beams to higher energies.

Details of the achievement were presented at the American Physical Society April Meeting in Denver.

"It is great to see the subject of near-threshold charmonium production emerge in the 12 GeV era of Jefferson Lab. The interest in this topic is substantially increased by recent reports of charmonium pentaquark states at CERN, as well as implications for fundamental aspects of Quantum Chromodynamics," said Robert McKeown, Jefferson Lab's Deputy Director for Science.

Quarks are the basic building blocks of the particles that build our visible universe. There are six quarks: up, down, strange, charm, bottom and top. The least massive, up and down quarks, are the constituent building blocks of protons and neutrons.

Particles containing the least massive quarks require the least energy to produce in particle accelerators, such as Jefferson Lab's Continuous Electron Beam Accelerator Facility, a DOE Office of Science User Facility. For instance, up, down and strange quarks have long been studied at Jefferson Lab. Producing the next quark on the list, however, required more energy than the original CEBAF could provide.

The new capability was made possible by an upgrade of CEBAF that tripled its original design operating energy to 12 billion electron-volts, or 12 GeV.

"For us, it's important because you can't produce a J/ψ until a certain energy, which is 8.2 GeV. Before the 12 GeV era, we didn't have

electron energies that high," said Colin Gleason, a postdoctoral research fellow at Indiana University. "But now, we can see how J/ψ's cross section, as we call it, turns on. There's some very interesting physics that you can study just by the shape of what the cross section looks like as you increase the beam energy."

Gleason and his colleagues produce J/ψ particles in the Gluonic Excitations Experiment. GlueX is designed to produce and study hybrid mesons to help nuclear physicists understand the role that gluons, the particles responsible for binding quarks together, play in the structure of matter. GlueX has completed its first phase of data taking, and the experimental collaboration has already begun preparations for the data analysis phase.

The experiment also allows for the study of other phenomena, such as the production of J/ψ in photon-proton collisions. The J/ψ, discovered in 1974, was the first evidence for the existence of charm quarks.

While billions of these particles have been produced in accelerators around the world, Jefferson Lab is unique in its ability to study the production of this particle in photon-proton collisions at low energies, close to the production threshold. Preliminary analysis of the GlueX data is beginning to elucidate the mechanisms for how J/ψ is produced. In addition, the study of J/ψ production by photons in the energy range available at Jefferson Lab allows nuclear physicists to take a fresh look at the phenomenon of five-quark baryons recently reported by the LHCb experiment at CERN.

"I will be talking about the things we measure when we're searching for hybrid mesons, and I'll be talking about the analysis needed in order to search for them, as well as recent results from the experiment, such as J/ψ production," Gleason said.

Gleason presented the preliminary results from the GlueX experiment at the American Physical Society April Meeting in Denver on Sunday, April 14.

Provided by Thomas Jefferson National Accelerator Facility