Jerry Gilfoyle <ggilfoyl111@gmail.com>

A&S Faculty Research Committee - Summer Fellowship Application

1 message

noreply@qemailserver.com <noreply@qemailserver.com> Fri, Oct 17, 2014 at 1:23 PM
Reply-To: trigger@qemailserver.com
To: ggilfoyl@richmond.edu

Your application has been successfully submitted. Please see a copy of your responses below for your records. Thank you.

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Response Summary:

Total Requested (currently the maximum is $6,000)
$6,000

Your Department
Physics

Mailing Address
Physics Department, 28 Westhampton Way, Richmond, VA

Academic Rank
full professor

Are you tenured?
Yes

Are you tenure track?
Yes

Highest degree attained
doctorate

Type of Fellowship (choose one)
Stipend

Please upload a 2-page curriculum vitae listing publications and presentations over the past 5 years...
http://ut1.qualtrics.com/WRQualtricsControlPanel/File.php?F=F_2tudZhck9XEGpIF

Project title
Looking for Quarks Inside the Neutron

Project description. Include background, main objectives, methods, and significance to your discipli...
We intend to probe the structure of the neutron by measuring the distribution of electric charge and electric

currents inside it. Below we discuss the scientific background of this work and its significance to nuclear physics. We outline the objectives, the methods and a work plan for achieving those goals.

One of the grand challenges in physics is to take our knowledge of the fundamental particles of nature (called quarks) and describe how they bind together to form protons, neutrons (called collectively nucleons), and atomic nuclei. The theory of interactions among quarks Quantum Chromodynamics (QCD) was developed in the 1970's and the developers (Gross, Politzer, and Wilczek) were awarded the Nobel Prize in 2004. However, we are still unable to start from QCD and derive the long-known properties of protons, neutrons, and nuclei. The calculations are difficult and there is little data to guide us. We had to wait for the next generation of accelerators like the Thomas Jefferson National Accelerator Facility (JLab) in Newport News, VA to perform the experiments to guide our theory.

We will focus on measuring the magnetic form factor of the neutron. This quantity is closely related to the neutron's charge and current distributions. If we are going to apply QCD to the neutron we have to be able to describe where the charges are located and how they move. These data are significant for the discipline because the neutron magnetic form factor has been measured before, but never to the depth we will probe here. We are in a region where we can finally start to unravel the neutron's quark structure.

Our experimental method requires the break-up of the simplest nucleus, the deuteron, which consists of a single proton and neutron. Free neutrons do not exist in nature so we use the simplest, neutron-containing nucleus as our target. At JLab we use a high-energy beam of electrons much like a powerful electron microscope. The electrons move close to the speed of light in a mile-long accelerator and collide with the nucleons in the deuteron. The pattern of the debris from this collision, the directions and energies and their probabilities, is determined by the quarks and QCD. This debris is collected in a large, 45-ton detector called CLAS12 which measures the trajectories and energies of the particles. Data are gathered electronically at a high rate; about 100 megabytes/second (equivalent to reading `War and Peace' in less than a second) and stored for analysis.

The CLAS12 detector is now being built at JLab and is near completion. We are part of a large collaboration responsible for the construction and later operation of CLAS12. We are now writing the computer programs that will take this deluge of data and turn it into the information that will enable us to reconstruct what happened in the collision and extract the the neutron magnetic form factor. This software requires a sophisticated service-oriented environment. A service here is a software component (i.e. a piece of code or a data structure) that is reusable and access is provided using a well-defined interface. This environment enables our team to build complex systems from many smaller components/services in a flexible and robust way. We will be focused on creating the code to reconstruct, simulate, and analyze the CLAS12 datastream and to prepare for the experiment to measure the neutron magnetic form factor. The JLab leadership has set for us the goal to have the software ready at first beam. This is an exciting and intense time at JLab as we approach first beam in CLAS12.

Is this project new?
No

Briefly describe project status and results to date. (300 word limit)

This project is part of the 12 GeV Upgrade at JLab; a $310M project to double the electron beam energy, build new detectors, and open new physics opportunities. The accelerator upgrade is complete and new detectors are coming online. The CLAS12 detector now under construction is a large, 45-ton, particle detector about three stories high, with eight different sub-systems that will measure the momentum and determine the identity of the debris from high-energy collisions of the electron beam with nuclear targets. It is scheduled to see first beam in summer, 2016 and the JLab leadership has challenged the Collaboration to be ready to reconstruct and analyze the data at startup.

My role is in the CLAS12 Software Group which is responsible for the reconstruction, simulation, and analysis of the 5-10 TB (1 TB = 1000 gigabytes) of data we will collect each day when experiments begin. We will build an array of computers to handle this data deluge consisting of about 12,000 cores/CPUs. It is essential for the software to be robust, reliable, and correct! My work on the project began several years ago and I have developed simulation and reconstruction software for two major CLAS12 subsystems. More is planned. We are developing additional reconstruction software to match the measurements in different subsystems to improve the overall resolution of CLAS12 to meet the design goals. We will also begin work on analyzing the trajectories of particles in CLAS12 to precisely test the locations of the different components and improve the precision of the momentum measurements in the detector.

This project has already resulted in refereed publications and five JLab technical reports in the last three years. Those technical publications have included undergraduate authors. We have not received University support specifically for this project.