Collaborative Research: Open Access Amplitude Analysis on a Grid

Project Summary

Intellectual Merit: This project proposes the development of an innovative data analysis framework that will catalyze efficient collaboration between phenomenologists and experimentalists, a crucial step in advancing the understanding of quantum chromodynamics (QCD). QCD, the theory that describes the force between quarks and gluons, must explain the experimental fact that quarks and gluons are confined in hadrons. The theoretical investigation of this confinement in QCD by seeking analytical solutions is intractable, but formulating QCD on a discrete space-time lattice (LQCD) shows great promise. LQCD calculations reveal that the gluonic field between quarks manifests itself in so-called "flux tubes," which are ultimately responsible for the confinement of the quarks. Excitations of these flux tubes lead to exotic hybrid mesons, a new family of particles that exhibit both quark and gluonic degrees of freedom. The experimental observation of these exotic mesons, and a mapping of their spectrum, is essential for quantitatively understanding the nature and inner workings of confinement.

Discovering this new family of particles will require a three-legged approach that includes a beam of the appropriate energy and type to produce exotics, a modern detector to measure their decay products, and a sophisticated suite of phenomenology-based analysis tools to extract the signals for exotic mesons from the large data sets that will be collected. The first two requirements will be met by critical components of the planned 12 GeV Upgrade of the CEBAF accelerator: the construction of a 9 GeV linearly polarized photon beam line and the GlueX detector. The final leg, the development of amplitude analysis tools and underlying phenomenology, is the focus of this proposal.

Historical attempts to extract results from data have been hindered by the lack of quality and quantity of data and the inability to understand the theoretical biases introduced by making specific simplifying assumptions in the analysis of the data. While former problem can be addressed with modern, high-statistics experiments, the latter will require theoretical expertise and innovative research at the intersection of physics and computer science. Lead by a research team with broad experience in experimental meson spectroscopy, phenomenology, grid computing, and software development, this project would fund the development of an analysis suite, built on the backbone of the Open Science Grid, that would allow transparent analysis of current and future experimental data. The collaboration among scientists that will be facilitated by this development will ultimately lead to a better understanding of QCD.

Broader Impact: Many of the key phenomenological ideas relevant to this research were introduced about thirty years ago, before the age of electronic publishing. Further development was stymied by the lack of experimental data. This project will utilize workshops and interviews to recapture this knowledge and archive it in both written and electronic form thereby allowing rapid dissemination to interested students and postdoctoral fellows. The open access nature of the analysis paradigm being developed in this project facilitates direct access to data by phenomenologists and their students for testing theoretical models and calculations. The tools developed will be open-source and could be utilized by future projects or experiments that desire enabling open access to data. More generally a high-level open access infrastructure lowers the barriers to engaging younger students in modern science. Internship opportunities may be available through existing projects dedicated to facilitating Cyberinfrastructure in minority serving institutions (MSI) such as MSI Cyberinfrastructure Empowerment Coallition (MSI-CIEC). In addition, MSI meetings provide a forum for presentations to encourage MSI involvement in the GlueX project.