JSA Initiatives Fund Request—Cover Page

Title	Photon-hadron physics with the GlueX detector at Jefferson Lab
Requesters	Curtis A. Meyer, Elke Aschenauer, Alex Dzierba, Jo Dudek, George Lolos and Christian Weiss
Position	Curtis Meyer is Spokesperson of the GlueX Collaboration and a Professor of Physics at CMU. Elke Aschenauer is head of the Hall-D group at JLab. Alex Dzierba is the past spokesperson of GlueX and a Professor of Physics at IU. Jo Dudek is a Professor of Physics at ODU. George Lolos is the chair of the GlueX collaboration board and a Professor of Physics at Univ. of Regina. Christian Weiss is a member of the JLab Theory Center.
Status	This is a **New** request.
Executive Summary	The GlueX experiment at Jefferson lab is a driving motivation for the CEBAF 12 GeV upgrade. GlueX addresses the fundamental question of confinement in QCD while the experimental program to carry this out has driven the choice of energy of the upgrade. The nature of this physics also demands a hermetic detector with good resolution. The GlueX collaboration has known for some time that there would be an extremely rich physics program possible within GlueX—a program that will extend far beyond the driving goal of QCD exotics. In order to expand both the physics program and the GlueX collaboration, we are planning a $2\frac{1}{2}$-day workshop to be held in late February or early March of 2008 with the purpose of making people aware of the physics possibilities that GlueX will provide as well as identify ways in which new collaborators could make important contributions to the experiment. We are requesting financial support from JSA to help facilitate this workshop.
Synopsis	The GlueX experiment is a critical part of the CEBAF 12GeV upgrade. However, due to the drawn out nature of Department of Energy Funding and the fact that the experiment required a new Hall, and thus had no running physics program at Jefferson Lab, the growth of the collaborations manpower has been unstable. It is important to attract new collaborators with new physics interest into GlueX. Both to realize its goals in the search for exotics and to significantly expand its physics program. This workshop aims to provide an environment where new people are made aware of the broad range of physics topics that can be carried out using GlueX. This should both strengthen the Gluex Collaboration, but also the Jefferson Lab user community as a whole.
Requested Funds	$ 10,000
Leveraged Funds	at least $7,000
Dates	$2\frac{1}{2}$ days in late February or early March of 2008.
Evaluation Plan	The measurable outcomes would be *new collaborators interested in new physics using GlueX* and *Letters of intent and possibly proposals to Jefferson Lab 12 GeV Program Advisory Committees.*

Photon-Hadron Physics With The GlueX Detector at Jefferson Lab

E. Aschenauer (JLab), A. R. Dzierba (IU), J. Dudek (ODU), G. Lolos (Regina),
C. A. Meyer (CMU) and C. Weiss (JLab)

15 October 2007

Executive Summary

The GlueX experiment at Jefferson lab is a driving motivation for the CEBAF 12 GeV upgrade. GlueX addresses the fundamental question of confinement in QCD while the experimental program to carry this out has driven the choice of energy of the upgrade. The nature of this physics also demands a hermetic detector with good resolution. The GlueX collaboration has known for some time that there would be an extremely rich physics program possible within GlueX—a program that will extend far beyond the driving goal of QCD exotics. In order to expand both the physics program and the GlueX collaboration, we are planning a $2\frac{1}{2}$-day workshop to be held in late February or early March of 2008 with the purpose of making people aware of the physics possibilities that GlueX will provide as well as identify ways in which new collaborators could make important contributions to the experiment. We are requesting financial support from SURA to help facilitate this workshop.

Introduction

The GlueX experiment, housed in a new photon-only hall (Hall D) at Jefferson Lab, is a crucial piece of the CEBAF 12-GeV upgrade. The main physics goals driving GlueX is the search for exotic and hybrid gluonic excitations in the meson spectrum, a problem whose significance has been widely recognized by the scientific community (a brief summary of the GlueX physics motivation is given in the following section). In addition to this well-known goal, there is a broad range of issues in hadronic physics which could be addressed using the Hall D photon beam and the GlueX detector, such as *e.g.* electromagnetic processes in meson production (Primakoff effect), charm production near threshold, high-t exclusive reactions, and nuclear effects. These topics have matured over the last couple of years and are now ripe for serious consideration by the scientific community.

With this proposal, we are requesting support for a $2\frac{1}{2}$-day workshop to be held at Jefferson Lab in late February or early March of 2008. This workshop will provide a forum in which these physics ideas can be discussed. Particularly in the context of carrying them out using the GlueX detector. In addition to identifying this new physics we also anticipate that the workshop will attract new collaborators to join GlueX and ultimately significantly broaden the entire physics program of the 12 GeV upgrade.

The Science Motivation of GlueX

An article in an August 2000 issue of the New York Times listed understanding confinement of quarks inside of protons and neutrons as one of the ten fundamental questions in physics to ponder for the 'next millennium or two'. Nearly all of the visible matter in the universe is forever trapped inside the nuclear cores of the atoms that we observe. While scientists believe that the theory of Quantum Chromodynamics, (QCD), can explain confinement, an exact understanding of how QCD works has been extremely elusive. We know that QCD works under the extreme conditions found in high energy particle collisions, but our knowledge of what it is doing under normal conditions found in the every day world is quite limited. Using advances in high speed computing and experimental facilities that could soon be available at laboratories in the United States, scientists hope to go a long way in answering this question within the next decade.

QCD is a theory that describes how quarks and gluons interact with each other. It was originally formulated based on experiments in the 60's and 70's, leading to many Nobel Prizes for experimentalists and theorists alike. QCD describes quarks as carrying three types of charge called color charge: red, green and blue. These names have nothing to do with the colors we are familiar with; it is only a naming scheme. However, like the colors we are familiar with, equal combinations of each color yields a white or color-neutral object. Each of these color charges can be positive or negative (quark or anti-quark). QCD requires that the combinations of quarks that can exist in nature are colorless. The simplest combinations satisfying this are called baryons (three quarks each of different color) and mesons (quark and anti-quark , color and anti-color).

In addition to the quarks and anti quarks, QCD has force-carrying particles called gluons which are exchanged between quarks and antiquarks to produce the force that holds matter together. What is unique about QCD is that the gluons also carry color; they are not white or neutral objects. It is exactly these colored gluons that allow for the complex nature of QCD, but have also made a complete understanding extremely elusive. We can solve for what quarks are doing when they are very close together, but when we try to look at something the size of a proton, all of our tools fail. Because gluons are not neutral, it should be possible for gluons to interact with each other to form matter containing only gluons with no quarks. All that is required is that the combinations are colorless. Combinations of two or three gluons will do the trick and such states are called glueballs. Other new mesons should also be possible and these would involve combinations of quarks and gluons called hybrid mesons. There are specific combinations that lead to hybrid mesons with quantum numbers that are not allowed for simple quark-anti-quark combinations, called exotic hybrid mesons. The beauty of these exotic hybrids arises from the fact that they cannot become mixed up with other mesons. Recent experimental results have hinted at the existence of a single such state, but the rich spectrum that would directly yield information on the confining force has so far been elusive. Taken as group, glueballs and hybrid mesons are known as gluonic matter or gluonic excitations. The GlueX experiment as part of the 12-GeV upgrade will carry out the measurements to identify these new states

Expanding the Physics of GlueX

The GlueX collaboration was formed in 1999 to tackle the confinement problem by designing a world-class experiment that would utilize high-energy linearly polarized photons to create and observe these gluonic excitations. The detector required to carry out this program needs to have very high acceptance and high-rate capabilities to collect enough quality data to significantly change the experimental situation. This is experiment is now the high-profile new detector being built as part of the CEBAF 12 GeV upgrade which is anticipated to reach a Department of Energy milestone known as *Critical Decision Two* (CD-2) late in 2007. The upgrade and the GlueX experiment are now about two years away from start of construction and now is a very opportune time for new collaborators to join the GlueX effort.

The GlueX collaboration has known for some time that there would be an extremely rich physics program possible within GlueX—a program that will extend far beyond the driving goal of QCD exotics. In order to facilitate this expansion, the collaboration is organizing a workshop to be held in late February of 2008 with the purpose of both significantly expanding the physics program within GlueX and hopefully attracting new collaborators to join. Such a workshop would both make people aware of the physics possibilities that GlueX will provide as well as identify ways in which new collaborators could make important contributions to the experiment.

The GlueX collaboration has established an organizing committee to make sure that the workshop will take place. In order to make sure that this occurs in a timely fashion, all committee members are either members of the GlueX collaboration or staff at Jefferson Lab. The members of this committee are as follows.

- Elke Aschenauer: Jefferson Lab. Elke is the Hall-D group leader at Jefferson Lab. She took this position after being Spokesperson of the HERMES experiment at DESY.

- Jozef Dudek: Old Dominion University. Jo is the current head of the GlueX theory contingent and was elected a member of the GlueX Collaboration Board in 2006.

- Alex Dzierba: Indiana University and Jefferson Lab. Alex has been one of the driving forces behind the GlueX collaboration and served as its spokesperson from the founding of the experiment through August of 2008.

- George Lolos: University of Regina. George has served as chair of the GlueX Collaboration Board for six years and will take over as Deputy Spokesperson in January of 2008.

- Curtis Meyer: Carnegie Mellon University. Curtis served as Deputy Spokesperson during Alex's tenure and was elected Spokesperson of GlueX in the summer of 2007. He is currently Spokesperson of GlueX.

- Christian Weiss: Jefferson Lab. Christian is a member of the Jefferson Lab theory group.

The committee has also identified several areas of physics interest that can be explored at the workshop. Many of these came from the early years of GlueX, but during the intervening years of trying to move GlueX and the upgrade forward, the ideas were somewhat sidelined due to lack of a proponent within the collaboration. It is felt that during the workshop, all of these topics should be addressed, both from a theoretical and an experimental standpoint. Thus one can motivate both why the physics is interesting and explore if it is possible using GlueX. A rough draft of the agenda by topics is presented in the following. This is not complete, but provides a framework for getting the workshop going. It is expected that people would also be able to present other ideas at the workshop.

I Introduction: The GlueX Detector
This session will present an overview of the initial capabilities of the GlueX detector and then discuss possible major upgrades. The nominal upgrades include better particle identification such as a Ring Imaging Cerenkov Detector (RICH) in the forward direction, and a detector for the Detection of Internally Reflected Cerenkov light (DIRC) in the central region.

II Chiral Anomaly and Primakoff Effect
A natural area of interest with the GlueX detector would be to continue the program of PrimeX which ran in Hall B. This is to use the so-called Primakov effect to study the two-photon couplings of mesons. One could also address issues of the Chiral Anomaly. Such a program would probably require upgrades to the forward calorimeter in GlueX.

III Charm Production Near Threshold
The $12\,GeV$ beams available open the possibility to study charm quark production near threshold. Both open charm in the form of $D\,\Lambda_c$ production and J/Ψ production are energetically possible using nominal GlueX photon beams. Such reactions may be able to study gluon Generalized Parton Distributions (GPDs) and effects associated with coherent multi-gluon reactions. On nuclear targets, one could look for bound states and potentially study color Van-der-Waals forces.

IV Exclusive Reactions at High Momentum Transfer
The nominal data collected during the running of GlueX will be rich in data on reactions that could help explore the GPDs in a way that is highly complementary to what is planned with CLAS-12. Such reactions include *Real Compton scattering at high t* (WACS), *Exclusive Meson production at high t* and *Inverted deeply-virtual Compton scattering* (DVCS).

VI Nuclear Effects in Photoproduction
There is also a program of experiments using nuclear targets in place of the normal hydrogen target in GlueX. Photo-nuclear reactions could allow one to study *Color Transparency* in high-t reactions. In addition, Hadron attenuation in the nuclear medium could be studied as well as effects on the properties of hadrons when they are imbedded in the nuclear medium.

V Spectroscopy
This session will present an overview of current status of meson and baryon spectroscopy. It will then present the planned meson spectroscopy program of GlueX as well extensions to this. Finally, it will discuss possibilities of extending the current JLab program in Baryon spectroscopy utilizing both the linear polarization and the higher beam energy.

VI Other Ideas
This workshop will also include a section of contributed *ideas* for physics that could be carried out. It is very important that this be left open to new and exciting ideas that the organizing committee failed to recognize.

Workshop Outcomes

This workshop has several desired outcomes which we list as follows.

- Assess broad range of new physics topics which can be addressed using the GlueX detector in conjunction with the Hall-D photon beam at Jefferson Lab.
- Increase awareness of physics opportunities with JLab 12 GeV.
- Prepare formulation of LOI's and proposals to 12 GeV PAC.
- Attract new collaborators to GlueX, with particular emphasis on those interested in exploring new physics opportunities.

In terms of measuring the success of this workshop, there are several clear metrics that can be applied. The first is the attendance of the workshop itself. A larger and broader attendance is likely to better meet the ultimate goals of the workshop. Beyond that, there is the addition of new collaborators to the the GlueX experiment and finally letters of intent and proposals to the Jefferson Lab Program Advisory Committee (PAC).

Budget Needs for a Successful Workshop

In order to make this workshop successful, it is clear that financial support will be needed. The most expensive component of such an endeavor is the travel expenses that would need to be covered for key speakers at the workshop. There are also costs associated with disseminating the results of the workshop. While this can be done on the web, it would be important to have some published proceedings to the workshop. For a 2002 Workshop at Carnegie Mellon University on Partial Wave Analysis, we found a very cost-effective way using the *International Journal of Modern Physics* ***A***. The generation of proceedings forces people to start to write down ideas and can seed letters of intent. Finally, there is support for local amenities such as coffee breaks and a reception. Because of the desire to have as

large a participation as possible, it is felt that the workshop should avoid a registration fee if at all possible.

Based on experience with other workshops, it is felt that approximately $20,000 will be needed to make the workshop successful. The organizing committee has already gotten committed support from Jefferson lab at the level of $5,000 and from Carnegie Mellon University at the level of $2,000. We are also looking for additional support from other universities. With this proposal, we are requesting support from SURA for this workshop at the level of $10,000.

JSA Initiatives Fund Request—Budget Page

Salary		
	Subtotal Salary	$ 0.00
Fringe		$ 0.00
Equipment		$ 0.00
	Subtotal Equipment	$ 0.00
Travel	Travel Support for key workshop participants	$ 8,000.00
Supplies	Workshop supplies such printed material, name tags, note pads	$ 250.00
Consultants		$ 0.00
Other Expenses	Publication support for conference proceedings	$ 1,750.00
	Budget Total	**$ 10,000.00**

Budget Justification

We anticipate a total budget of about $ 20,000, of which $5,000 has been secured from Jefferson Lab and $ 2,000 from Carnegie Mellon University. We are currently pursuing funds from other universities. The workshop will be held at Jefferson Lab, so we have little or no cost for the local conference support. If we have to, we will charge a nominal workshop fee, However at this point in time, we would like to avoid doing that.

The *travel* amount, supplemented by money from the non-JSA money will be used to support key people to attend the conference. A number of the world experts are retired and would require full support to be able to attend. In addition, it is likely that we will need to provide some level of support to bring in international participants. We anticipate some of our other funds supplementing the $8,000 in this request. Our anticipated numbers are not to different from other 50 to 60 person conferences that we have organized.

The *supplies* number will go to support the actual running of the conference. This number will likely be supplemented from other sources.

The *Other Expenses* will be used to publish proceedings from the workshop. Getting the participants to produce written proceedings will help facilitate the generation of letters of intent to the summer PAC at JLab. It will also provide an excellent reference on the physics possibilities within GlueX. The number given here will need to be about twice this size based on experience with journals such as the *Journal of Modern Physics A*.

Other expenses not mentioned here will include coffee and tea for breaks and an opening reception. There will also be expenses associated with producing and mailing out advertisement for the workshop.