Supplemental Grant Request to Medium Energy Nuclear Physics Research at the University of Richmond

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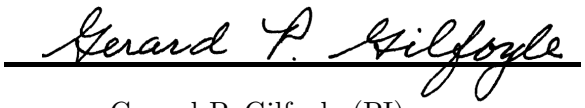
Office of Nuclear Physics: Medium Energy Nuclear Physics Program
Program Manager: Dr. Ted Barnes

Abstract

This is a supplemental grant request to support a joint University of Richmond/University of Surrey masters student as part of the Richmond program in electromagnetic nuclear physics at the Thomas Jefferson National Accelerator Facility (JLab). The masters student will be focused on developing software to investigate the neutron magnetic form G_M^n. The student will be stationed as JLab, but will travel frequently to the nearby University of Richmond.

Amount Requested: $45,773



Gerard P. Gilfoyle (PI)

1 Plan of Work

This is a supplemental grant request to support a joint University of Richmond/University of Surrey masters student each year as part of the Richmond program in electromagnetic nuclear physics at the Thomas Jefferson National Accelerator Facility (JLab). Dr. G.P. Gilfoyle is the principle investigator (PI) and the relevant physics projects are listed in Table 1. This list is a subset of the Richmond program and includes projects appropriate for a masters thesis. Below we discuss

Title	Label
Measurement of the Neutron Magnetic Form Factor at High Q^2 Using the Ratio Method on Deuterium (Gilfoyle: spokesperson and contact person)	E12-07-104
The Neutron Magnetic Form Factor from Precision Measurements of the Ratio of Quasielastic Measurement of the Neutron Magnetic Form Factor at High Q^2 Using the Ratio Method on Electron-Neutron to Electron-Proton Scattering in Deuterium	E94-017
CLAS12 Software Architecture	
Precision measurement of the neutron magnetic form factor up to Q^2 = 18 $(GeV/c)^2$ by the ratio method	E12-09-019

Table 1: Summary of physics projects of the Richmond group.

the physics motivation for the Plan of Work, our technical projects, how the masters student will contribute, and the qualifications of our leading candidate.

The elastic electromagnetic form factors are basic observables that describe the distribution of charge and magnetization inside the proton and neutron. Their measurement is a goal of the current NSAC Long-Range Plan [1], it is Milestone HP4 in the DOE Performance Measures [2], and it forms a central part of the past and future physics programs at Jefferson Lab (JLab) [3, 4, 5]. We are part of a broad assault on the four elastic nucleon form factors (electric and magnetic ones each for the proton and neutron) at JLab that include six experiments approved for running in the first five years after the 12 GeV Upgrade is complete [4, 5]. The Upgrade will double the beam energy and expand the physics reach of the Laboratory. We focus here on the neutron magnetic form factor G_M^n. (1) Gilfoyle is the spokesperson and contact person for JLab experiment E12-07-104 to measure G_M^n in Hall B using the CLAS12 detector now being built. (2) We have also taken on the analysis of existing data collected with the current detector in Hall B (CLAS6) to extract G_M^n.

Our technical projects are aimed primarily on software development to prepare for E12-07-104 and the analysis of the existing G_M^n data. Modern high energy and nuclear physics experiments require more computing power to keep up with increasing experimental data volumes while at the same time functioning within large, diverse collaborations. We will require about 2,000 CPUs to keep up with the CLAS12 dataflow when beam arrives [6, 7]. For the CLAS Collaboration to successfully analyze this dataflow requires accurate, adaptable, and efficient code.

The traditional physics computing model of monolithic software applications running in batch mode is difficult to maintain, hard for new users to use, and less adaptable to modern multi-core, multi-threaded, distributed computing environments. The CLAS12 Software Group is developing a service-oriented architecture (SOA) to solve this problem called CLARA (CLAS12 Reconstruction and Analysis framework). A service here is a software component (*i.e.* a piece of code or a data structure) that is reusable and where the access is provided using a well-defined interface. The use of the interface has to be consistent with constraints and policies specified by the service description. The services are loosely couple meaning each each service/component has little or no knowledge of

other services, *i.e.* the electron tracking code consists of a chain of services (segment finding, linking segments together, *etc.*) that are independent of one another [8]. Much of the early development of CLARA used the Richmond physics cluster (obtained with an NSF MRI grant in 2010 [9]).

We are among the earliest users and developers of the CLAS12 software tools including CLARA to prepare for the G_M^n experiment [10, 11]. Our group is responsible for developing software for the simulation and analysis of CLAS12 data. We are working on improving the simulation of the CLAS12 electromagnetic calorimeter and using the CLARA-based reconstruction code to study the CLAS12 response to neutrons. These topics are ones where the masters student could make a significant contribution in their research year and learn the skills for modern software development.

We will also analyze existing data from the E5 run period to extract G_M^n at $Q^2 < 1$ (GeV/c)^2. Some of these data have already been published at higher Q^2 [12]. We have preliminary results for the $Q^2 < 1$ (GeV/c)^2 range that agree with Anderson *et al.*, but are about 6-7% below the results of Anklin *at al.* and Kubon *et al.* [13, 14, 15]. Resolving these differences will clarify our understanding of G_M^n in this region. We expect statistical and systematic uncertainties of about 3% each and the E5 data set has abundant overlaps and consistency checks to insure the quality of the results. This is an excellent opportunity to improve our understanding of nucleon structure with data we already have in hand. The analysis tools for this project are fairly well-developed, but we need to apply them to this data set. The masters student would push this analysis along and learn the skills to perform physics analysis on large data sets.

We request in this proposal funding to support a masters-level student who will be engaged in the physics projects described above. Our group at the University of Richmond consists of a single faculty member and 2-4 undergraduates working during the summers. The addition of a 12-month masters student would raise our productivity and enhance the intellectual environment in our research group and in the Physics Department at the University of Richmond.

The proposed masters student would be part of a joint program between Richmond and the University of Surrey in the UK. Undergraduate physics majors at Surrey normally graduate in three years, but some apply and are selected to receive a masters degree in physics that includes a year of research. These are the students who would be funded by this program. In physics skills they are equivalent to first-year graduate students in the United States. We propose to support one of these students each year starting in January, 2013. The program runs from January to December in each calendar year. The program director at Surrey, Prof. P. Regan, is enthusiastic about the opportunity for their masters students to do research at JLab. We request funds only for an annual stipend; there are no tuition costs.

We have thought carefully about how to structure this student's experience. (1) We would station the person in the Richmond office at Jefferson Lab. Gilfoyle routinely travels to JLab; he spent 63 days on site during the last year so there would be ample time for for collaboration. Gilfoyle is an active member of the CLAS12 Software group and the group provides a good working environment and community to work in. Three JLab staff scientists (Weygand, Gyurjyan, Ungaro) in the group are committed to supporting this student. (2) The student would spend some time (2-4 days per month) in Richmond typically on the Physics Department's seminar days. The University of Richmond is a primarily undergraduate institution and the Physics Department does not usually have graduate students. This would broaden the masters student's perspective by working in a university setting, interacting with Richmond undergraduates, and collaborating with the PI. In this proposal we ask for funding for this travel. (3) The program proposed here covers a significant range of topics from analysis of CLAS6 data to developing new tools for the CLAS12. We will work closely with the our collaborators at JLab and at Surrey to match the student's skills and interest to the needs of the program. This is an exciting time at JLab and the program outlined here would embed the student in that community, provide abundant opportunities for working with the PI,

and also give the student a taste of a university environment. (4) We will make excellent use of the Richmond physics computing cluster (240 CPUs) mentioned above. This system has been a major development tool for the CLAS Collaboration and provides an ideal environment for the masters student to learn about high-performance computing.

It is worth mentioning that this collaboration with Surrey has been a success in the nuclear structure community at Yale, Kentucky, Florida State, Notre Dame, LBL, and even Richmond (through a faculty colleague, Dr. Con Beausang). Those programs benefited from the Surrey students and many of the students have gone on to US graduate schools, enhancing the US workforce. We also point out that stationing the masters student at JLab dramatically cuts the overhead rate.

The curriculum vitae of the candidate we have selected for the research year at JLab is listed in Section 4. Mr. Alex Colvill is a strong candidate with excellent grades in his coursework. Grades about 60% are considered good enough to obtain a doctoral scholarship and over 70% is excellent. Mr. Colvill had an average of 75% in the first year of the masters program at Surrey and 82% in the first semester of the second year. He also has several years of experience in software development in industry using C^{++} and Java which will be very helpful for the projects described above. Mr. Colvill is a promising candidate for the research year at JLab.

We now summarize. We are preparing for JLab experiment E12-07-104 to measure the neutron magnetic form factor G_M^n after the 12 GeV Upgrade. The Richmond group will develop software resources to simulate, reconstruct, and analyze data from CLAS12. We will also pick up the analysis of the remaining data set from the E5 run period to extract G_M^n from existing CLAS6 data. We request funds for a masters student from the University of Surrey to support this program and enhance our productivity and the intellectual environment for our undergraduate researchers and the Physics Department at Richmond. The budget is shown in Table 2.

2 Budget and Justification

Student Salary[1]	26,200
Fringe Benefits[2]	6,812
Total Salaries, Wages, and Fringe Benefits.	33,012
Travel 1[3]	3,828
Travel 2[4]	2,000
Total Direct Costs	38,840
Indirect Costs[5]	6,933
Total Direct and Indirect Costs	45,773

Table 2: Budget for Richmond/Surrey masters student for January-December, 2013.

1. Total salary (no tuition costs).
2. 26% for the masters student.
3. Weekly visits to Richmond - Based on twelve visits to Richmond during the 14-week semester and five visits during the summer.
4. Travel to present poster at DNP meeting.
5. 21% of salaries, wages, and fringe benefits for the masters student who will spend more than 50% of their time away from the University of Richmond.

3 References

[1] Nuclear Science Advisory Committee. *The Frontiers of Nuclear Science*. US Department of Energy, 2007.

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[8] V. Gyurjyan, D. Abbott, G.P. Gilfoyle, J. Carbonneau, G. Heyes, S. Paul, C. Timmer, D. Wyegand, and E. Wolin. CLARA: A Contemporary Approach to Physics Data Processing. *Jour. of Phys. Open Access Conference Proc.*, 2011.

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[10] Gilfoyle G.P., M. Ungaro, Carbonneau J., M. Moog, and C. Musalo. Simulation of the Electromagnetic Calorimeter in CLAS12. CLAS-Note 2011-019, Jefferson Lab, 2011.

[11] Gilfoyle G.P., M. Ungaro, Carbonneau J., M. Moog, and C. Musalo. Simulated CLAS12 Neutron Detection Efficiency in the Forward Time-of-Flight System. CLAS-Note 2011-015, Jefferson Lab, 2011.

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[13] B. Anderson et al. *Phys. Rev. C*, 75:034003, 2007.

[14] H. Anklin et al. *Phys. Lett. B*, 336:313–318, 1994.

[15] G. Kubon et al. *Phys. Lett. B*, 524:26–32, 2002.

4 Biographical Sketch: Surrey Masters student

ALEX COLVILL

Address: Pointers South, Pointers Road, Cobham, Surrey, KT11 1PQ.
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Email: ac00214@surrey.ac.uk

EDUCATION

Surrey University (10-now)		Masters in Physics in progress 1st year average: 75% (gained performance grant) 2nd year, 1st semester average: 82%
Open University	(*99–06*)	1st class degree in Information Technology and Computing (incl. C++, Java); additional Certificates in Mathematics and Quantitative Studies for Business
Derby University	*(97-99)*	Foundation in Engineering
Godalming College, Surrey.	*(95-97)*	A levels – Biology, Chemistry and Psychology
Tonbridge School, Kent.	*(92-95)*	*9* GCSEs
Downsend School, Leatherhead, Surrey.	*(86–92)*	Scholarship to Tonbridge School

CAREER SUMMARY

May 08 – now **Trained and worked as a self-employed Electrician**

Achievements:

- Currently self-funding my Surrey University degree.

Nov 05 – April 08 **PNI Digital Media (formerly Pixology)** **Configuration Engineer**

Responsibilities:

- High-level creation and alteration of digital photo kiosk software using bespoke design tools to create new business and maintain relationships with existing customers such as Tesco, Boots and Asda in the UK, and Costco and Walgreens in the US.
- Management and implementation of the software update process.

Achievements:

- Progressing from my original position of kiosk software tester (manual, mainly functional testing, both web and non-web based) to the newly created post of configuration engineer. This shows my ability to negotiate (the existence of the post), to teach myself new technical skills (including requirements analysis, .wse scripting and visual programming) and to take on new responsibilities, with direct impact on household name clients.
- Creation of the current software updates process to cope with a system that would otherwise have been impractical, thus saving time and money. This shows my ability to use my own initiative to improve complex processes.

Mar 04 – Aug 05 **Electronic Arts** **Games Tester**

Responsibilities:

- Finding and logging faults in computer games for the largest computer games company in the world.

Achievements:

- Having my contract extended a number of times due to my success as a software tester, showing my ability to analyse, and fault find in, complex systems.

Aug 99 – Mar 04 **Brooklands, Excel Logistics, Digital Audio Systems and private individuals.**

Temporary Assignments

Achievements:

- Self-funded my Open University degree and certificates.

INTERESTS

Regular tennis, squash and skiing to stay fit. Crime fiction. Strategy games.