Application for a Full-Year, Enhanced-Salary Sabbatical Leave

G.P. Gilfoyle

The components of this part of the application follows the numbering in the application instructions under the heading of Application Procedures.[1]

1. **Opening statement**
   I am applying for a full-year, enhanced-salary sabbatical or topping off my sabbatical salary during the 2022-2023 academic year. Taking this full-year leave is contingent upon receiving adequate support from both external funding agencies and the University. If I do not receive the additional support I would prefer to be on leave for a single semester during the spring, 2023 semester.

2. **External funding proposals**
   Below is the list of external grant applications. Note that I do not give specific salary amounts. That feature is explained below.
   (a) Proposal 1
      i. Nuclear Physics Program Research grant
      ii. Office of Science, US Dept of Energy
      iii. Funds were requested to support travel costs for a one-year sabbatical at JLab in addition to summer salaries, summer student stipends, travel, *etc.* Total budget was $275,000 for three years.
      iv. Submitted Nov 23, 2020
      v. Approved April, 2021
   (b) Proposal 2
      i. Jefferson Laboratory Operations Research Support
      ii. Southeastern Universities Research Association
      iii. Travel support $27,000
      iv. Submitted October 7, 2021
      v. Approved Jan 6, 2022

   Some explanation is needed for the budget. Item 2.a is a three-year, renewable grant for my research from the US Department of Energy (DOE) that covers the period June 1, 2021 - May 31, 2024. DOE supports my research in nuclear physics at Jefferson Lab (JLab) in Newport News, VA which includes indirect costs DOE pays to the University for administration, general maintenance, and other expenses. In November, 2020 when I submitted my renewal proposal I included travel funds for my sabbatical in addition to other items like travel, materials, and supplies to support my research program and my students. A summer salary for me was part of the renewal plus stipends for my students. In 2021 I began discussions with the staff at JLab to fund my academic

[1] Application Instructions for a Full-Year, Enhanced-Salary Sabbatical Leave `https://asadmin.richmond.edu/_common/pdf/dean-office/sabbatical-forms/enhanced_sabbatical.pdf`, last accessed Jan 11, 2022.

year salary for the sabbatical. They were supportive, but JLab is no longer supporting sabbatical salaries as they have done in the past. I received sabbatical salary from JLab before. Nevertheless the JLab administration was willing to provide travel funds for me to live in Newport News during my sabbatical. See Item 2.b above. I also considered other sources, but none provided salary. At this point I had more than enough travel money, but no salary support.

I then had an exchange with my Program Officer Dr. Gulshan Rai at the Department of Energy. I proposed to move money in the DOE grant (item 2.a) for travel, materials, and supplies into salary for me. This grant reallocation would be a step toward replacing the missing part of my salary. Dr. Rai supported this change. The loss in the the travel, materials, and supplies accounts would be mitigated by using funds from my Research Incentive and Loving Chair indices.[2] My students and I would still be able to do our research until my next renewal comes up in 2024. I have worked with Amanda Salazar, the Grants Account Manager in the University's Controller's office. She provided the numbers below and has the documentation from my DOE Program Officer granting permission to make these changes. The funds available and associated budget categories are in Table 1 below.

Item	Amount
Salary	\$25,252
Fringe Benefits*	\$6,919
Indirect Costs†	\$16,728
Indirect Costs to UR‡	\$15,055
Total	\$48,899

* Fringe benefits are 27.4% of salary.
† Indirect costs are 52% of salary plus fringe benefits.
‡ University's portion of indirect costs.

Table 1. Budget description for reallocated DOE grant funds.

The total of \$48,899 is the amount now in the DOE grant for travel, materials, and supplies. The reallocation of these funds follows DOE rules so they cover fringe benefits and include indirect costs. The indirect costs (\$16,728) go to the University for administration, general maintenance, and other expenses. The University has a policy where ten percent of indirect costs from external grants (\$1,672.80 here) are returned to the researcher who received the grant. These funds go into a Research Incentive index to be used for professional development (no salary). Thus, the University will receive \$15,055 in indirect costs from this proposed reallocation of funds in the grant. I will still have the JLab funds (item 2.b, Proposal 2 above) that will reimburse me for travel costs (only) associated with this sabbatical.

The salary listed in Table 1 covers about one-sixth of my total academic year salary which still leaves a large hole in my income. If I take a one-year sabbatical

[2] I am the holder of the Robert and Lena Loving Chair in Physics which provides funds for professional development. The University returns 10% of indirect costs contributed by external grants in a Research Incentive index for the researcher. Neither index can be used for salary.

with the grant reallocation described here, but without the enhanced-salary sabbatical or topping off I would still lose more than 30% of my total academic-year salary. The enhanced-salary sabbatical or topping off puts the one-year sabbatical within my reach. Compare the indirect costs to be received by the University from the grant reallocation, $15,055, with the maximum University award of $20,000. The indirect costs in the grant reallocation cover most of the University award. If I don't take a one-year sabbatical the grant reallocation does not occur. The additional funds of the enhanced-salary sabbatical or the topping off program would enable me to devote the full year to my research at JLab. In the past making progress during sabbatical was essential to maintain my DOE funding. I am able to begin new projects and climb the learning curve needed to perform them. This momentum carries me through periods when my teaching and service duties limit the time available for research. I have been supported by DOE since 1990.

3. **Project Description**

The nuclear physics program at the University of Richmond is focused on the structure of matter and the transition from the hadronic picture of matter (atomic nuclei viewed as composed of protons and neutrons) to a more fundamental description in terms of quarks and gluons. We use the Thomas Jefferson National Accelerator Facility (JLab) in Newport News, VA to measure the charge and current distributions of the neutron by scattering a high-energy electron beam off a nuclear (deuterium) target. We are using JLab like a powerful electron microscope. In particular, we will measure the distribution of electric current in the neutron - a quantity known as the neutron magnetic form factor or by its mathematical symbol G_M^n. In JLab experiment E12-07-104 (spokesperson: Gilfoyle) we have collected data to measure G_M^n at high Q^2 where Q^2 is the size of the momentum 'kick' imparted to the target by the electron beam. The higher the Q^2 the smaller the size of features we can image with the electron beam. We 'image' the neutron interior by extracting the properties (energy and momentum) of the debris from the collisions of the electron beam with the deuterium target. We are part of a large collaboration working to reconstruct, analyze, and simulate data from these experiments and many others from the CLAS12 detector housed in Hall B at JLab. The CLAS12 detector is a large (30-feet high) particle detector that records the passage of sub-atomic particles after the collisions. We typically collect about 30-40 terabytes of data per day during experiments (30,000 - 40,000 gigabytes). We have also made a preliminary measurement of the CLAS12 neutron detection efficiency needed to precisely determine G_M^n from the recent deuterium runs. We have also continued our work to develop and enhance the software tools used in our collaboration.

This is a sabbatical proposal to support the University of Richmond electromagnetic nuclear physics research program at JLab using the CLAS12 detector in Hall B. Dr. G.P. Gilfoyle is the principle investigator (PI) and full member of the CLAS Collaboration which operates CLAS12. The CLAS Collaboration is an organization consisting of about two hundred physicists from 43 institutions in 14 countries with the purpose to operate and maintain the CLAS12 detector and carry out its physics program. The PI's physics projects are listed in Table 2 below. The Richmond group has a joint program with the University of Surrey in the UK to support a masters student to do research at JLab. The group typically consists of the PI, 2-3 University of Richmond undergraduates, and a Surrey masters student. During sabbatical the PI will be stationed at JLab to take full advantage of the facilities and collaborators.

Our major focus now is on analysis of CLAS12 data collected recently to measure G_M^n, the magnetic form factor of the neutron. We are part of a broad program at JLab to measure the elastic, electromagnetic form factors consisting of seven experiments including two to measure G_M^n. The PI (Gilfoyle) is spokesperson and contact person for the CLAS12 G_M^n experiment (JLab Experiment E12-07-104) and is a collaborator on the Hall A G_M^n measurement (JLab experiment E12-09-019). Both experiments use methods pioneered in Hall B with the previous detector CLAS6 [1]. The PI is one of the lead authors on that work.

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
CLAS12 Software	
Quark Propagation and Hadron Formation (Gilfoyle: co-spokesperson)	E12-06-117
Precision measurement of the neutron magnetic form factor up to $Q^2 = 18\ (GeV/c)^2$ by the ratio method (different JLab collaboration)	E12-09-019

Table 2. Summary of physics projects of the Richmond group. The label is for projects approved by the JLab Physics Advisory Committee.

Our measurement uses the ratio of detected electron-neutron ($e - n$) events to detected electron-proton ($e - p$) events scattered from a deuterium target to extract G_M^n. Deuterium is used as the target because it contains a single neutron and proton. We have completed the first round of deuterium runs as part of Run Group B in Hall B and accumulated 39 days of beamtime over three time periods. We collected 43 billion triggers at three electron beam energies (10.2, 10.4, and 10.6 GeV). Initial calibration and analysis of the data sets are complete. The PI was run coordinator for the spring, 2019 and winter, 2020 run periods (total of 18 days). The run coordinator is responsible for the day-to-day operation of CLAS12 during data collection and to see that the physics program is fulfilled. The RC is also responsible for coordinating the CLAS12 operations with the JLab accelerator management and other JLab operations. The G_M^n analysis is moving forward with the development of event selection criteria for the $e - n$ and $e - p$ events used in the ratio. Analysis projects like these at JLab typically take years to complete. Here, we have collaborated with Dr. B.Raue from Florida International University (FIU) and his doctoral student Ms. L. Baashen.

An essential quantity in our analysis is the neutron detection efficiency (NDE) to provide an accurate measure of the number of $e - n$ events. We rely on data from electron scattering on a liquid hydrogen target to determine the NDE. Neutrons are electrically neutral and harder to detect than other, charged particles like protons. The NDE corrects for these missing neutrons in the $e-n/e-p$ ratio. To measure the NDE we use the $^1\mathrm{H}(\mathrm{e}, \mathrm{e}'\pi^+\mathrm{n})$ nuclear reaction where the electron beam scatters off a proton target and we detect the scattered electron, a sub-atomic particle called a pion (π^+) and the neutron (n). Detecting all the particles enables us to use the conservation of momentum and energy to determine the neutron momentum and extract the NDE. Our preliminary results are the topic of a contributed talk at the fall, 2020 APS Division of Nuclear Physics (DNP) meeting [2]. The precision of our results at high neutron momentum (corresponding to high Q^2) is encouraging [2].

We will also continue our commitment to develop software for the simulation, reconstruction, and analysis of CLAS12 data. We used codes written by two former Richmond undergraduates (K.Sherman and A.Balsamo) to extract the G_M^n ratio from deuterium data and to determine the NDE from the hydrogen data. The codes were originally tested and validated using the physics-based simulation of the CLAS12 detector called *gemc*. Accurate simulations are an essential tool for the design and analysis of data from large particle detectors. The *gemc* simulation uses the same software 'factory' now used in proton beam cancer treatments. Both codes have been used successfully in the current G_M^n analysis [3,4,5]. We also updated and expanded reconstruction software tests used to ensure consistent results from the code [6,7] and determined the resolution of the reconstruction software in simulation [8].

We will support the operations of the Hall B CLAS12 study of the prototype pixelated micro-well detector (MWD) and to develop and deploy software for the operation of the MWD and/or the analysis of data collected with it. The central goal is to measure and characterize the performance of the prototype. The motivation is to use a MWD in the CLAS12 detector to increase its operational data-collection rate and bring new physics within reach. A micro-well detector consists of an array of tiny, individual gas counters that detect the passage of charge particles (like a set of Geiger counters). The wells may be connected in crossed strips to provide full, three-dimensional reconstruction of particle tracks with large volumes. This technology has been used to build fast, efficient, and precise gas tracking detectors and it can be used to construct large-area devices with a low material budget. This low material budget is important because it reduces the impact of multiple scattering which can reduce the precision of the detector. The time is ripe for this project. The group at the University of Virginia is developing a prototype MWD for fall, 2022 that could be used by Run Group C (one of the CLAS12 run groups). See the file gilfoyleJLabProposal.pdf in the materials submitted with this application.

During this sabbatical the PI will continue the collaboration with FIU to complete the analysis of the G_M^n data and contribute to the software effort for CLAS12. The PI's sabbatical will occur during the later stages of the G_M^n analysis so he will be well-positioned to contribute to that work. We have developed simulations to study ways to optimize the analysis, *e.g.* reduce neutral backgrounds and increase the signal size. We have just begun to study methods for *in situ* monitoring of the NDE using neutrons from reactions on the same deuterium target we use to determine the neutron magnetic form factor G_M^n.We will continue our contributions to the CLAS12 software development coordinating our work with Dr. V.Ziegler who is the lead developer for the CLAS12 reconstruction code.

References

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6. M. Armstrong, V. Ziegler, and G.P. Gilfoyle. Clas12 drift chamber reconstruction software unit test. CLAS12-Note 2020-02, Jefferson Lab, 2020. `https://misportal.jlab.org/mis/physics/clas12/viewFile.cfm/2020-002.pdf?documentId=67`.

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8. A. Saina, V. Ziegler, and G.P. Gilfoyle. The CLAS12 Reconstruction Resolution. In *Bull. Am. Phys. Soc., Fall DNP Meeting*, 2020. PA.00017.

4. **Submitted proposals**

   The two proposals relevant to this application are included as attachments to the email containing this submission. The files are the following.

   (a) gilfoyleDOEproposal2020.pdf - three-year, renewable proposal submitted to the US DOE in fall, 2020. Narrative part begins on page 17.

   (b) gilfoyleJLabProposal.pdf - proposal submitted to JLab administration for sabbatical travel support in summer, 2021.

5. **Curriculum vitae for Gilfoyle**

   This document is also attached as a file to this email. The filename is gilfoyleCV.pdf