Abstract

We propose to develop a partnership between Jefferson Lab's (JLab) Continuous Electron Beam Accelerator Facility (CEBAF) in Newport News, VA and the Idaho Accelerator Center (IAC) at Idaho State University. The partnership will initially be nurtured through a research and development project designed to construct a positron source for the CEBAF. The first year of this proposal will be used to benchmark the predictions of our current simulation with positron production efficiency measurements at the IAC. The second year will use the benchmarked simulation to design a beamline configuration which optimizes positron production efficiency while minimizing radioactive waste. The second year will also be used to design and construct a positron converter capable of sustaining the heat load from high luminosity positron production. The final year will quantify the performance of the positron source and measure the source's radiation footprint. A joint research and development project to construct a positron source for use by the CEBAF will bring together the experiences of both electron accelerator facilities and solidify this partnership for future projects. Our intention is to use the project as a spring board towards developing a program of accelerator based research and education which will train students to meet the needs of both facilities as well as provide a pool of trained scientists.

The Development of a Positron Source for JLab at the IAC

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Joe Grames, Andrew Hutton

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Application Cover Page for Notice #: DE-PS02-07ER07-15

May 10, 2009

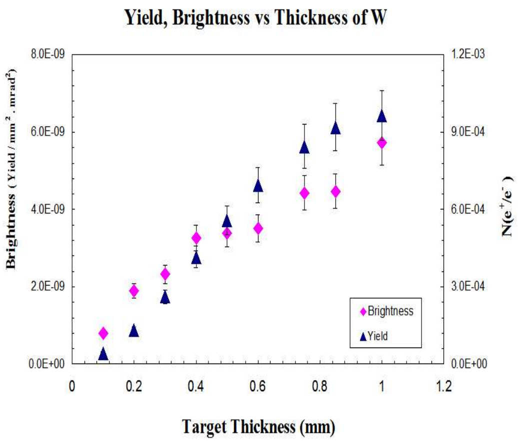
1 Project Objectives

We propose to develop a partnership between Jefferson Lab's (JLab) Continuous Electron Beam Accelerator Facility (CEBAF) in Newport News, VA and the Idaho Accelerator Center (IAC) at Idaho State University. The partnership will initially be nurtured through a research and development project designed to construct a positron source for the CEBAF. The first year of this proposal will be used to benchmark the predictions of our current simulation [1] with positron production efficiency measurements using an IAC electron accelerator. The second year will use the benchmarked simulation to design a beamline configuration which optimizes positron production efficiency. The second year will also be devoted to designing a positron converter capable of sustaining the heat load from high positron luminosity production. The final year will be used to measure the capabilities of the positron source and the source's radiation footprint. A joint research and development project to construct a positron source for use by the CEBAF will bring together the experiences of both electron accelerator facilities and solidify a partnership for future projects.

One of the more common methods used to create positrons is to bombard a target of high atomic number (Z), typically Tungsten, with electrons of sufficient energy to generate a shower of secondary electrons, photons, and positrons. Electron accelerators have used this technique to produce positron beams with intensities approaching $10^7 e^+$/sec [2] at 100 MeV energies that are at least an order of magnitude larger than traditional radioactive source based beams [3]. Positron beams have also been produced at GeV beam energies with intensities of $10^{10} e^+$/sec for use by the high energy physics community. The implementation of a positron source at JLab can be done by creating positrons at the injector, or at a substantially larger cost, construct a positron source using one of the GeV beamlines. Because of the expected high cost, it is believed that a positron source near the injector would be a more cost effective strategy.

Polarized electrons from the present CEBAF injector can exit the first cold cryo-unit with a maximum energy of 8.5 MeV before being accelerator to 50 MeV after two additional cryomodules and then entering the main CEFAB accelerator ring. The current conceptual design of a positron source for use at the CEBAF would rely on the production of positrons at these relatively lower energies (MeV). Positrons would be produced using electrons from the current source which have been accelerated to energies between 10 and 16

MeV. Although these low energies produce less intense positron beams, our current simulation predicts that we will be able to produce positron currents beyond a nanoamp which are sufficient for our needs. This energy selection has the feature of being close to the 10 MeV neutron production threshold [4] allowing us to reduce radioactive waste.



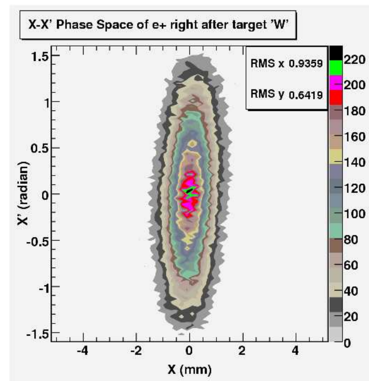


Figure 1: The left figure illustrates the Positron Yield, $N(e^+/e^-)$, and Brightness as a function of converter thickness when 10 MeV electrons impinge on a Tungsten target. The phase space (x -vs- x') for positrons leaving a 0.5 mm thick Tungsten target is shown in the left figure.

1.1 Year 1 Objectives

The main objective of this proposal, in the first year, will be to perform positron production measurements using an IAC electron accelerator in order to benchmark our simulation [1]. As shown in Figure 1, the simulation predicts an almost linear increase in positron production efficiency, $N(e^+/e^-)$, as the tungsten converter target thickness increases when using 10 MeV electrons. The trajectories of the positrons leaving the converter will also impact the efficiency of injecting a beam of positrons for acceleration in the CEBAF. Emittance (ε_x) is defined as

$$\varepsilon_x = \sqrt{< x^2 >< x'^2 > - < xx' >^2} \quad (1)$$

where x is distance of the positron from the beam center along the beamline as it leaves the Tungsten converter and x' is the angle of the positrons momentum with respect to the beam axis given by $\arctan(\frac{p_x}{p_z})$, an example is shown in Figure 1. Defined in this manner, the emittance simultaneously accounts for both the location of emission and the direction. Decreasing the emittance will increase the number of positrons transported into the accelerator.

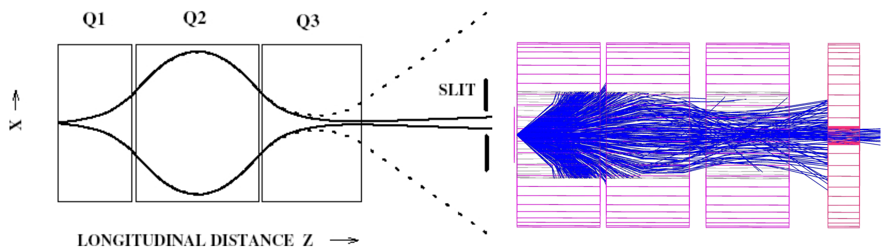


Figure 2: The left image illustrates the positron transport system conceptual design using three quadrapole magnets whereas the right image represents the positron trajectories predicted by the simulation.

Brightness, defined as

$$B = \frac{N(e^+)}{\varepsilon_x * \varepsilon_y}, \tag{2}$$

is one of the parameters used to evaluate the optimal target thickness by simultaneously taking into account positron production and emittance. The variable $N(e^+)$ represents the number of positrons from the converter and ε_y represents the emittance in the vertical beam direction. The simulation predicts a plateau in the Brightness, see Figure 1, when the Tungsten target thickness is 0.5 mm. The simulation also predicts the 0.5 mm thickness to be optimal in terms of the positron production efficiency per Watt of deposited energy when using 10 MeV incident electrons. Our objective in year one will be to evaluate the veracity of the above predictions.

The transport of positrons from the Tungsten converter to the accelerator is envisioned to be a three quadrapole system based on the work of Reference [5]. Figure 2 shows the current conceptual design and the positron trajectories predicted by our simulation of the system. The quadrapole triplet system will select a positron momentum band as well as divert electrons and positrons which are out of the accelerator acceptance. Figure 3 shows the dependence of the positron momentum with positron efficiency as predicted by the simulation. The simulation predicts that a 0.5 mm thick Tungsten target placed in front of a 10 MeV electron beam will produce the most positrons in a momentum band between 3 and 5 MeV. Based on this prediction, the transport system has been designed to deliver positrons with a momentum distribution shown in Figure 3.

The goal in year 1 will be to confirm these predictions with measurements using an IAC electron accelerator and different Tungsten target thicknesses. A Faraday cup will need to be purchased and installed early in year 1 for these measurements. The magnet system will be provided by our DOE lab partner, the CEBAF, and the remaining beamline components will be provided by the IAC. The IAC has several HP-Ge detectors to measure the energy spectrum at low intensities as well as neutron sensitive scintillators (BC420), and position sensitive ionization chambers to measure attributes of the positrons exiting the converter at higher intensities and perform a preliminary evaluation of the source's radiation footprint.

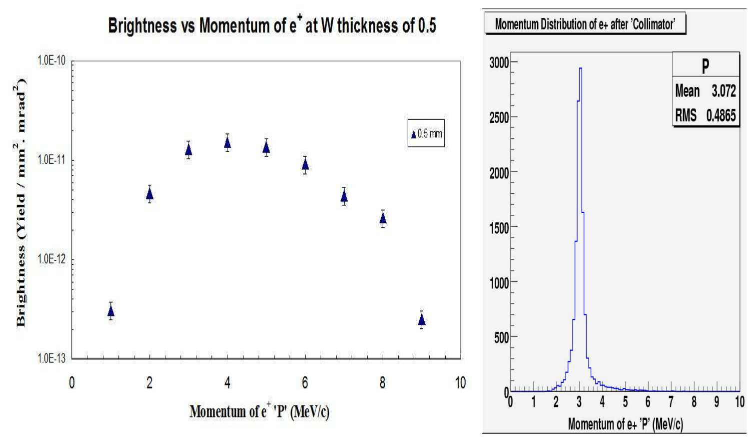


Figure 3: The above figures are predictions from our current simulation. The left figure illustrates the positron production Brightness as a function of the positron's momentum leaving a 0.5 mm thick target. The right image shows the positron momentum distribution leaving the quad tripled transport system shown in Figure 2.

1.2 Year 2 Objectives

The second year will use the benchmarked simulation to design an optimal beamline configuration, perform heat load studies using an IAC electron accelerator, and construct a positron converter target which can sustain a high heat load. We expect at least another iteration of measurements using IAC facilities in order to benchmark the simulation during the first part of year 2. During those measurements we will also perform heat load studies by spanning the accelerator's instantaneous current range from dark current (nA) to 80 mA and increasing the energy from 5 MeV to at least 15 MeV. Table 1.2 is the simulation's prediction for the heat load on each transport element when using a 0.5mm Tungsten target and a 10 MeV electron beam to generate a 20 nA beam of positrons. The final checks between the simulation and data are expected to be completed midway through year two as well as the heat load measurements. A chamber for the Tungsten converter will be designed and constructed to house a brushless motor used to rotate the target. A conceptual design of the system's general features is shown in Figure 4. A quote for the typical cost of a brushless motor to rotate the converter was used to determine the budget allocation of $15,000 for the motor.

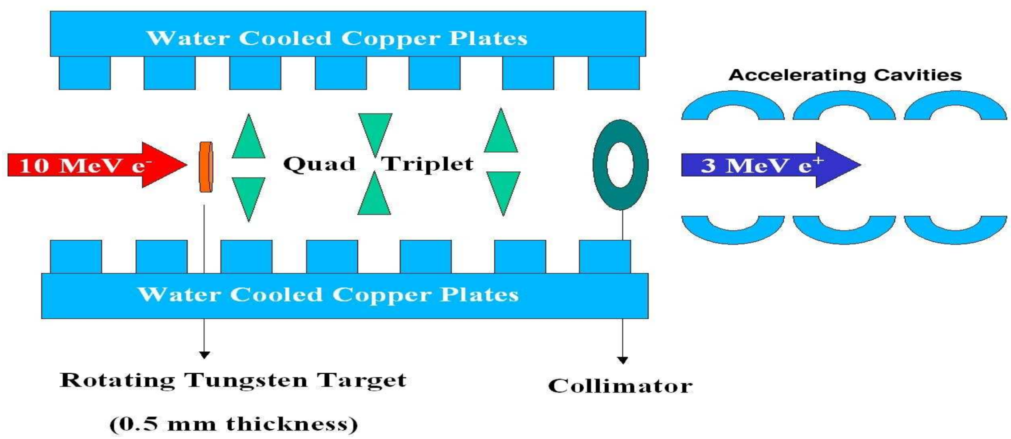


Figure 4: Conceptual cooling system. Electrons from the CEBAF's present source would impinge a Tungsten converter disk which is rotating to improve its heat load capacity. Water cooled copper plates are heat sinked to the converter and triplet magnet system. The 3 MeV positrons are then injected into the CEBAF.

Heat Load per Transport System Element	
Element	Power (kW)
Tungsten Target	22
First Quad Magnet	25
Second Quad Magnet	15
Third Quad Magnet	5
Collimator	28

1.3 Year 3 Objectives

The final year will be used to quantify the performance of the positron source, measure the source's radiation footprint, and hold a workshop to review the positron source's performance in order to determine a path towards implementing a positron source at the CEBAF. The first half of the year will be devoted to measuring the positron production rates and emittance with in house detectors. The Faraday cup installed in year one will be used to measure the positron current. We expect to only spend a small amount of the beam time match provided by the IAC on this measurement since it was the focus of measurements made during years 1 and 2. The remaining beam time will be spent measuring the amount of extraneous radiation which will not be injected into the CEBAF in order to determine the environmental impact of using the source at JLab. The positron emittance will be measured using two ionization chambers equipped with Gas Electron Amplifiers [6] that enable spatial resolutions of least 100 μm [7]. The radiation footprint of the source will be measured using the above ionization chambers for charged particles, a HP-Ge detector for photons, and a BC420 scintillator for neutrons. A workshop will be organized at the end of this project which will bring together CEBAF personnel, IAC personnel, and experimentalists interested in using this positron source. One of the main goals of this workshop will be to present the positron source design for review and formulate a path forward for its implementation in the CEBAF.

2 Project Timetable

The project timeline is shown in Table 2. The timeline below is organized with a quarterly reporting system in mind. The first quarter will be used to complete the beamline design for experiments using an IAC electron accelerator followed by construction of the beam line and installation of a Faraday cup by the second quarter. The next quarter will be used to gather and analyze positron production data and report those results in the fourth quarter. The positron converter design should be completed by the fifth quarter and be constructed by the end of the sixth quarter. Two quarters will be absorbed to schedule the installation and commissioning of the positron converter system. Quarters 7 & 8 will also serve as a time contingency in case items from previous quarters experience delays. The final year will spend two quarters measuring attributes of the source and the last two quarters of the project will be used to organize a workshop to present the design for review and formulate a path forward for its use.

Project Schedule	
MASD*	Milestone
3	Complete positron beam line design
6	Complete positron beam line construction and installation of Faraday cup
12	complete positron production efficiency measurements
15	Complete high power positron converter design
18	Complete high power positron converter construction
24	Complete installation of high power positron converter
30	Complete measurements of positron source parameters
36	Hold workshop entitled "Positron Production at JLab"
48	Publish workshop proceedings
*Months After Start Date	

3 Project Performance Site

The Idaho Accelerator Center (IAC) was created as a result of the Nuclear Science Application Project (NSAP), a successful effort begun by Idaho State University (ISU) in the late 1980's to develop strength in nuclear-based applied research. NSAP began in 1988 when the ISU Physics Department established the Particle Beam Laboratory. The IAC became a State approved research center in 1994. The IAC building was completed in October 1998 and was dedicated on April 30, 1999. By 2000 the IAC had about 20,000 sq.

ft. of laboratory space. The latest additions to the IAC were completed in the summer of 2004. The complex now has some 40,000 sq. ft. of laboratory and office space along with 15 acres of open land for field testing see Figure 5 in Appendix D.

During the founding period and to the present there has been cooperation between the IAC and the DOE for a wide range of joint activities, governed by a Memorandum of Understanding (MOU). This MOU outlines the collaborative efforts between INEEL, ISU, and the DOE and allows the placement of DOE owned equipment at ISU. The MOU provides for a relationship under which the IAC houses DOE owned equipment, but uses ISU facilities and personnel for operation, maintenance and health and safety guidance. A significant advantage of this agreement is the ease with which equipment is shared between universities, government agencies, and the private sector in a unique research environment. This environment centralizes equipment in a convenient location fostering inexpensive research and development and rapid testing for integrated demonstration development and transfer of technology. Over the last 10 years the IAC has had contracts and grants totaling over $15M with a wide range of government and private organizations.

The Idaho Accelerator Center (IAC), located less than a mile away from campus, will provide a machining facility for the construction of the beamline and positron source. Among its many operating accelerator systems, the Center houses a Linac capable of delivering 20 ns to 2 μs electron pulses with an instantaneous current of 80 mA up to an energy of 25 MeV at pulse rates up to 1kHz. This proposal plans on using the 25 MeV Linac to perform the measurements indicated in section 1. We anticipate that the positron source will be sent to JLab upon completion of the work in this proposal for further testing under high current conditions. The IAC has donated beam time for this proposal which amounts to a cost sharing contribution equal to 15% of the total budget.

A complete description of the facility is available at the web site (www.iac.isu.edu).

4 The CEBAF-IAC partnership

Talks towards a collaboration between the CEBAF and the IAC began in December of 2006. The discussions were centered around establishing a relationship between the two labs for the purpose of educating scientists in accelerator physics and providng students with hands on experiences. The CEBAF is a production facility with limited resources for research and development. The IAC provides a unique facility which combines the features of a research based accelerator facility with the educational attributes of a University. This provides ample opportunity for accelerator based research and development as well as training students. The project outlined in this proposal will be the first joint effort between the two facilities.

A Memorandum of Understanding (MOU) will be used to describe the general features of the CEBAF-IAC partnership for accelerator physics based education and research. The roles of each partner specific to this R&D project are given below.

- Arne Freyberger and graduate student Serkan Golge will design a beam line for the IAC
- CEBAF will provide the magnets needed to transport positrons into a shielded cell at the IAC.
- The IAC will provide a 16 MeV electron beam and beam pipe to enclose the primary and secondary beams.
- Both partners will provide manpower for the research project.

5 Project's importance and Relevance to DOE's Mission

The Department of Energy has identified 5 strategic themes which its strategic goals have been formulated to promote in order to satisfy its mission. "Strengthening U.S. scientific discovery" and "Ensuring America's nuclear security" are two of the themes listed which resonate with both the CEBAF and the IAC. Both accelerator facilities have a record of DOE funding for the purpose of scientific discovery. The IAC also has a research program to image cargo containers with electron accelerator based probes for the purpose of improving homeland security against nuclear threats. By forming this partnership, CEBAF will expand its scientific discovery potential with the addition of a positron source and the IAC will acquire infrastructure to quantify beam properties which will open up new avenues of fundamental physics measurements. The work in this proposal will be the impetus for a program of education and training between both facilities that can enhance the mission of each as well as the DOE's overarching mission

The scientific program at Jefferson Lab can benefit in at least three areas. First, the use of charge symmetric probes is one of the most direct methods to evaluate two photon exchange processes. There is a current disagreement between electro-magnetic form factor measurements extracted from asymmetries measured using polarized beams and targets and experiments which rely on Rosenbluth separation with unpolarized beams and targets [8]. Two photon exchange has been cited as the cause of this discrepancy and there are several proposals to measure the relevant amplitudes. Secondly, e^+ and e^- charge asymmetry measurements may be used to measure the interference between Bethe-Heitler and Deeply Virtual Compton Scattering (DVCS) in order to extract DVCS amplitudes and access generalized parton distributions that are used to describe the non-perturbative aspects of a nucleon [9]. Thirdly, the search for a low energy U-boson is an area of scientific discovery which can be probed by the $e^+e^- \rightarrow U\gamma$ reaction and contribute information towards unraveling the mystery of the abundant 511 keV photons observed at the Galactic Center [10]. The availability of a positron source at JLab will result in the ability to investigate controversies which have come to light as a result of JLab's original form factor measurement mission as well as extend that mission into the area of generalized parton distributions and the search for a low energy U-boson.

The direct benefits of developing a positron source at the IAC are two fold. The extra instrumentation of the IAC beamline will allow the IAC to expand its experimental program to include absolute measurements of fundamental cross sections for use in their homeland security program. A second benefit is the continued use of a positron source proto-type at the IAC after some changes are made in order to extract "slow" positrons. These changes would be part of a separate project which if successful would improve the IAC's abilities to probe for defects in materials. Metal fatigue has been identified as the dominant source of mechanical failures [11] which in 1982 was estimated to cost the U.S. economy $119 billion. The IAC has demonstrated the feasibility of defect measurements in the past [12] but it has not established a full time user facility. The development of an intense positron source will allow the IAC to reap the above benefits.

Appendices

A Biographical Sketch

A.1 Dr. Tony Forest (PI)

A.1.1 Education and Training

Univ. of Ill. at Champaign-Urbana , Urbana, IL	Ph.D. Exp. Nuclear Physics ,May 1998
Western Michigan University, Kalamazoo, MI	M.A. Th. Nuclear Physics, June 1991
Colorado State University, Pueblo, CO	B.S. Math and Physics. May 1987

A.1.2 Research and Professional Experience

Idaho State University	Pocatello,ID
Associate Professor	9/06 - present

- Constructing ionization based radiation detectors equipped with gas electron amplification.

Louisiana Tech University	Ruston, LA
Assistant Professor	9/00 - 8/06

- Developed ionization based radiation detectors equipped with gas electron amplification.
- Established Data Acquisition lab utilizing single board computers (PPC604) running VxWorks and hosted by a PC running the Linux operating system.
- Established pulsed X-ray Lab to test detector technologies.
- Received NSF funding for two separate research proposals.

Old Dominion University	Norfolk, VA
Postdoctoral Associate	6/98 - 8/00

- Coordinated multiple inter-disciplinary groups in a 2 year fundamental research project to isolate spin physics properties of the proton.

- Developed Semi-Inclusive experimental program in Hall B for JLAB high energy proposal White Paper.
- Established veracity of Hall B Moller polarimeter.
- Installed hardware and software for monitoring helicity dependence of beam current, online, in Hall B.
- Developed online monitor of experimental running conditions; target, beam, and physics events.

University of Illinois at Urbana-Champaign Urbana, IL
Research Assistant 8/91- 5/98

- Constructed Cerenkov radiation detector enclosing a 12 m^3 volume and utilizing a highly polished mirror collection system to focus the Cerenkov light onto 10, 8” photomultiplier tubes at MIT-Bates.
- Established Data Acquisition system based on CODA.
- Performed photo-multiplier detector calibration and linearity tests.
- Measured energy spectrum of back scattered electrons using a Sodium Iodide (NaI) crystals.
- Developed data analysis package with dynamic histogramming and event testing software for use on HP unix systems. Data Acquisition experience using Q at MIT Bates. Cryogenic target operator experience at MIT Bates on SAMPLE and TJNAF on E89-12 experiments.

A.1.3 Select Publication List

- Quark-Hadron Duality in Spin Structure Functions g1p and g1d, Phys. Rev. C, 74, (2007), 035203 (hep-ph/0607283), P.E. Bosted, K.V. Dharmawardane, G.E. Dodge, T.A. Forest, S.E. Kuhn, Y.Prok, for the CLAS Collaboration.
- Measurement of the x- and Q2- dependence of the spin asymmetry A1 of the Nucleon,Phys. Lett. B 641,(2006) 11, K.V. Dharmawardane, P.E. Bosted, G.E. Dodge, T.A. Forest, S.E. Kuhn, Y.Prok, for the CLAS Collaboration.

- Experimental Determination of the Evolution of the Bjorken Integral at Low $Q^2$2, Phys. Rev. Lett. 93, 212001, 2004, A. Duer, et. al.

- Measurement of the Spin Structure Function g1(x,Q^2) from 0.15 to 1.6 GeV^2 with CLAS, Phys. Rev. Lett. 91, 222002, 2003, Fatemi for the CLAS Collaboration.

- Measurement of Inclusive Spin Structure Fuctions of the Deuteron with CLAS, Phys. Rev. C67, 055204 (2003) , J. Yun, S. Kuhn, G. Dodge, T.A. Forest for the CLAS Collaboration.

A.1.4 Synergistic Activities

2006-present	Member of the Idaho State University Radiation Safety Committee
2003-2005	Faculty Senator for Louisiana Tech's Faculty Senate
2003-2005	Chair of Technology Committee for Louisiana Tech's College of Engineering and Science

A.2 Dr. Alan Hunt (Co-PI)

A.2.1 Education and Training

Harvard University	Ph.D. Physics ,May 2000
University of Michigan	B.S., June 1994

A.2.2 Research and Professional Experience

2006-present	Deputy Director, Idaho Accelerator Center at Idaho State University
2007-present	Associate Research Professor (tenured) at Idaho State University
2002-2007	Assistant Research Professor (tenure track) at Idaho State University
2001-2002	Research Associate Professor at Washington State University
1998-1999	Student Term Employee at Lawrence Livermore National Laboratory

A.2.3 Select Publication List

- Monte Carlo simulations of slow-positron production from normal and glancing incident targets M. A. Gagliardi and A. W. Hunt Nuclear Instruments & Methods in Physics Research B 245, 355 (2006)

- Intense slow positron production at the 15 MeV LINAC at Argonne National Laboratory H. M. Chen, Y. C. Jean, C. D. Jonah, S. Chemerisov, A. F. Wagner, D. M. Schrader and A. W. Hunt Applied Surface Science 252, 3159 (2006)

- Gamma-induced positron annihilation spectroscopy and application to radiation-damaged alloys D. P. Wells, A. W. Hunt, L. Tchelidze, J. Kumar, K. Smith, S. Thompson, F. Selim, J. Williams, J. F. Harmon, S. Maloy and A. Roy Nuclear Instruments & Methods in Physics Research A 562, 688 (2006)

- Defect imaging of structural objects using positron annihilation spectroscopy A. W. Hunt, R. Spaulding, J. Urban-Klaehn, J. F. Harmon and D. P. Wells Nuclear Instruments & Methods in Physics Research B 241, 362 (2005)

- The development of the intense positron beam at Washington State University A. W. Hunt, L. Pilant, D. B. Cassidy, R. Tjossem, M.

Shurtliff, M. H. Weber and K. G. Lynn Applied Surface Science 194, 296 (2002)

A.2.4 Synergistic Activities

2006-present	Chairman of Idaho State Universitys Radiation Safety Committee
2004-2006	Chairman of Idaho State Universitys Accelerator Safety Committee
2004	Outstanding Mentor Award in Siemens Westinghouse Competition
2003	Ralph E. Powe Junior Faculty Award from Oak Ridge Associated Universities

A.3 Khalid Chouffani (Research Faculty)

A.3.1 Education and Training

Catholic University of America, Washington D.C. Ph.D. Physics ,May 1996

A.3.2 Research and Professional Experience

- Exotic X-ray sources: Electron beam interaction with high power lasers and crystals. (Laser-Compton scattering, channeling radiation, parametric X-radiation).
- Electron beam diagnostic techniques:
- Laser-Compton scattering, Optical transition radiation
- Photo-injector LINACS.
- Optical logic gates (Design and testing)

2002-Present	Idaho State University, Associate Research professor
2004-2006	Director of COLD project optics laboratory
2001-2002	Idaho Accelerator Center, Postdoctoral position
1997-2000	VBL Department of Engineering, Hiroshima University, Research Physicist
1996-1997	Hansen Experimental Physics Laboratory Stanford University, Postdoc
1994- 1995	National Institute of Standards and Technology Gaithersburg MD

A.3.3 Select Publication List

- K. Chouffani, F. Harmon. D. Wells, J. Jones, G. Lancaster "Laser-Compton Scattering as a Tool for Electron beam diagnostics", Laser Part. Beams 24, (2006) 411.
- K. Chouffani, F. Harmon, D. Wells, J. Jones, G. Lancaster "Determination of Electron Beam Parameters by Means of Laser Compton Scattering", Phys. Rev. Spec. Top. AB 9, 050701 (2006).
- K. Chouffani, D. Wells, F. Harmon, G. Lancaster "Potential applications of Laser-Compton Scattering", Accelerator Applications in a Nuclear Renaissance, AccApp'03, (2004) 946.

- K. Chouffani, I. Endo and H. Berall "Axial Coherent Bremsstrahlung of type A", Nucl. Instr. and Meth. Phys. Research B 201, (2003) 16.
- K. Chouffani, D. Wells, F. Harmon, G. Lancaster "Laser-Compton Scattering from a 20 MeV Electron beam", Nucl. Instr. and Meth. Phys. Research A 495 (2002) 95.
- K. Chouffani, I. Endo and H. berall "Planar and axial Coherent Brem. of type A from a 17 MeV electron beam in a Diamond crystal". Phys. Rev. B 64, (2001) 014304.
- K. Chouffani "Electron Gun Cathode pulse measurement", RIKEN Beam physics and Engineering internal report (June 2000).
- K. Chouffani, H. berall, H. Genz, P. Hoffmann-Staschek, U. Nething, and A. Richter, "Low Energy Channeling Radiation experiments in a Germanium Crystal", Nucl. Instrum. And Meth. Phys. Research B 152 (1999) 479.
- K. Chouffani and H. berall, "Theory of Low Energy Channeling Radiation: Application to a Germanium Crystal", Phys. Stat. Sol. B 213 (1999) 107.
- K. Chouffani, H. berall, R. Dougherty, R. Fusina, H. Genz, P. Hoffmann-Staschek, U. Nething, and A. Richter,, "A Comparative Study of Coherent Brem. and Channeling Radiation", Nucl. Instrum. and Meth. Phys. Research B90 (1994) 133.

B Current and Pending Support

B.1 Dr. Tony Forest (PI)

Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Current NSF $152,842 8/31/07-7/1/09 2 summer months A Low Energy Standard Model Test via Polarized Electron Scattering at Jefferson Lab
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending DOE_EPSCOR $413,241 8/1/09-7/1/12 1.2 Months The Development of a Positron Source for JLab at the IAC
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending NSF $962,211 8/1/09-7/1/12 2 summer months A Program to Study Hadronic Matter using Electromagnetic Probes at Jefferson Lab
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending NEURP $722,238 7/1/09 - 6/30/12 1 summer month Photofission of Actinides with Linearly Polarized Photons

B.2 Dr. Alan Hunt (Co-PI)

Support Status:	Current
Source of Support:	DoD
Total Award Amount:	$1,383,000
Total Award Period Covered:	9/1/06-8/1/09
Person-Months per year Committed:	2
Project/Proposal Title:	Small Accelerator and Detection Systems
Support Status:	Current
Source of Support:	DoD
Total Award Amount:	$100,256
Total Award Period Covered:	12/1/08-12/1/2009
Person-Months per year Committed:	0.5
Project/Proposal Title:	Support of Large Standoff Fissionable material Detection for DTRA FY09
Support Status:	Current
Source of Support:	INL
Total Award Amount:	$49,503
Total Award Period Covered:	11/1/08-9/1/09
Person-Months per year Committed:	0.5
Project/Proposal Title:	High Energy Prompt Neutrons for the Detection of Fissionable Materials at Long Range
Support Status:	Current
Source of Support:	National Nuclear Security Admn.
Total Award Amount:	$598,450
Total Award Period Covered:	11/1/08-10/1/09
Person-Months per year Committed:	2
Project/Proposal Title:	High Repetition Rate, Linac based Nuclear Resonance Flourescence
Support Status:	Current
Source of Support:	CAES and INL
Total Award Amount:	$750,000
Total Award Period Covered:	5/1/07-9/1/09
Person-Months per year Committed:	2
Project/Proposal Title:	Enhancement of Separation Methods in Nuclear Fuel Recycling

Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Current DoD $1,112,741 11/1/07-12/1/10 2 Basic Research in High Sensitivity SNM Forensics via Correlated Photo Induced Emission Signatures for Topic B: Advanced Radiological Detection Forensics
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Current DOE $1,200,000 8/1/07-7/1/10 2 Incorporation of Novel Nanostructural Materials into Solar Cells and Nanoelectronic Devices
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending DoE through BEA $466,233 7/1/09-6/1/11 2 Near real-time Nondestructive Active Inspection Technologies Utilizing Delayed Gamma Rays for Advanced Safeguards
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending DOD $1,059,023 7/1/09-12/1/12 3 Brems-Based Photonuclear Long Range, Standoff Detection of SNM

Support Status:	Pending
Source of Support:	DOE_EPSCOR
Total Award Amount:	$413,241
Total Award Period Covered:	8/1/09-7/1/12
Person-Months per year Committed:	1.2
Project/Proposal Title:	The Development of a Positron Source for JLab at the IAC

B.3 Khalid Chouffani (Research Faculty)

Support Status:	Current
Source of Support:	DOE
Total Award Amount:	$449,384
Total Award Period Covered:	9/30/08-9/29/09
Person-Months per year Committed:	4
Project/Proposal Title:	Hybrid-K-edge/X-ray Flourescence Densitometry with Laser-Compton Scattering x-rays
Support Status:	Pending
Source of Support:	DOE
Total Award Amount:	$1,401,148
Total Award Period Covered:	2/1/09-1/31/12
Person-Months per year Committed:	4
Project/Proposal Title:	Development of a compact laser-Compton scattering x-ray source for for dynamic materials studies
Support Status:	Pending
Source of Support:	DOE
Total Award Amount:	$993,403
Total Award Period Covered:	4/1/09-3/31/12
Person-Months per year Committed:	4
Project/Proposal Title:	Laser-Compton Scattering as a tool for electron beam diagnostics

Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending DOD $403,438 1/1/10-12/31/10 4 Experimental investigation of Laser Compton Scattering as an X-ray source for mammography
Support Status: Source of Support: Total Award Amount: Total Award Period Covered: Person-Months per year Committed: Project/Proposal Title:	Pending DOE_EPSCOR $413,241 8/1/09-7/1/12 6 The Development of a Positron Source for JLab at the IAC

C Identification of Potential Conflicts of Interest/Bias in Selection of Reviewers

C.1 Collaborators and Co-editors

H. Areti, Jefferson Lab (JLab); S. A. Awadalla, Washington State University (WSU); D. Beller, University of Nevada Las Vegas (UNLV); D.H. Beck, Univ. of Ill Urbana-Champaign; B. Blackburn Idaho National Laboratory (INL); D. B. Cassidy, University of California Riverside; S. Chemersov, Argonne National Laboratory (ANL); H. Chen, University of Missouri Kansas City (UMKC); The CLAS collaboration; P. Cole, Idaho State University; D. Dale, Idaho State University; P. Debevic, Univ. of Illinois Urbana-Champaign; J. R. Dennison, Utah State University; E. B. Farfan, Savannah River; A. Freyberger, Jefferson Lab (JLab); H. Glass, Honeywell; J. Grames, Jefferson Lab (JLab); K. Haskel, INL; D. Hertzog, Univ. of Illinois Urbana-Champaign; A. Hunt, Idaho State University; A. Hutton, Jefferson Lab (JLab); Y. C. Jean, UMKC; C. D. Jonah, ANL; J. L. Jones, INL; S. Maloy, Los Alamos National Laboratory; V. Munne, Cermet Inc; B. McKeown, Caltech; N. Newman, Arizona State University; A. Nathan, Univ. of Illinois Urbana-Champaign; D. R. Norman, INL; D. Schrader, Marquette University; F. A. Selim, WSU; P. J. Simpson, University of Western Ontario; K. Smith, International Atomic Energy Agency; J. W. Sterbentz, INL; C. Szeles, IIVI Inc.; R. Tjossem, WSU; A. F. Wagner, ANL; M. H. Weber, WSU; S. H. Wei National Renewable Energy Laboratory; D. Wells, Idaho State University; J. Williams Pennsylvania State University; W. Y. Yoon, INL; J. M. Zabriskie, INL

C.2 Graduate and PostDoctoral Advisors and Advisees

C.2.1 Advisors

J. A. Golovchenko, Harvard University;D.H. Beck, Univ. of Illinois Champaign-Urbana

Postdoctoral Advisors:
K. G. Lynn, Washington State University; S. Kuhn, Old Dominion University

C.2.2 Advisees

M. A. Gagliardi, M.S. 2004, ISU; A. R. Hoskins, M.S. 2006, Idaho State University (ISU); C. S. Joseph, M.S. 2004, University of Massachusetts Lowell; M. T. Kinlaw, M.S. 2004, ISU; J. Kraft, M.S.2004 LaTech; M. Novovic, M.S.2003 LaTech; R. Rios, M.S. 2005, ISU

D Equipment

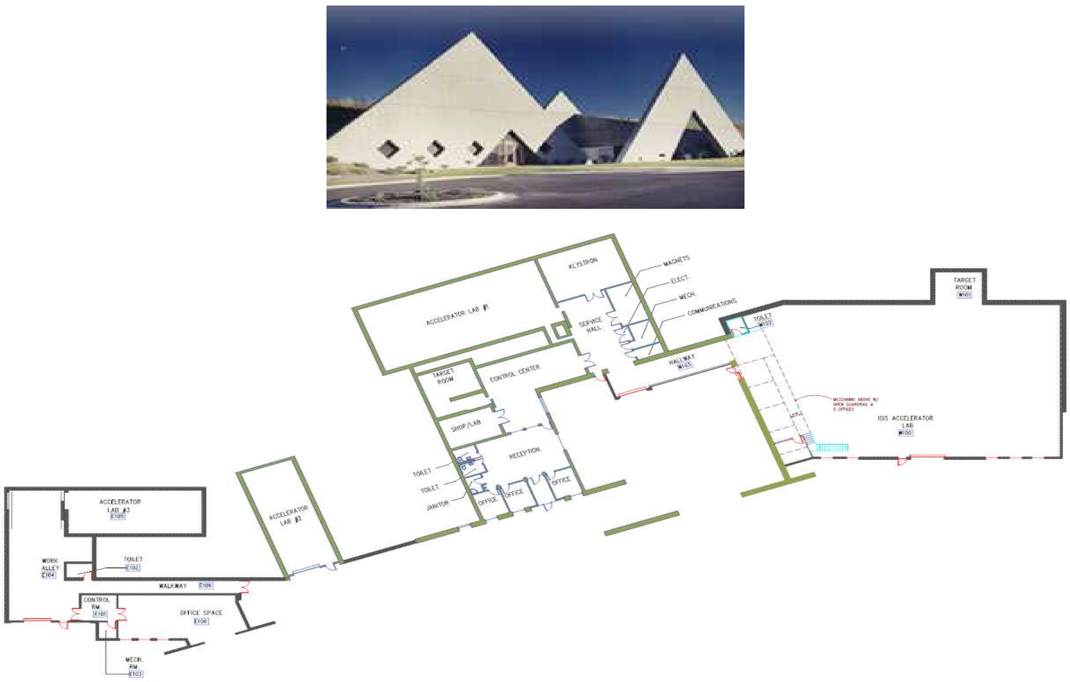


Figure 5: A picture of the IAC building appears in the top. The bottom is a floor plan of the facility which will be used for this project

- 25 MeV Linac; 80 ns $\rightarrow$ 2 μs electron pulses, 80 mAs per pulse, either single shot to 1 kHz pulse frequency;20 $\rightarrow$ 50 ns short pulse operation mode with 100 mAs per pulse.
- Machine shop: Mill, lathe, drill press tig welder.
- BC408 scintillator paddles with Photonics PMTs
- HpGe detector
- DAQ system

References

[1] M. A. Gagliadi adn A.W. Hunt, Nucl. Instr. and Meth., **B 245** (2006) 355-362; S. Golge, *et. al.*, Proceedings of PAC07, THPMS067, Albuquerque, New Mexico, 2007.

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[4] M. J. Berger and S. M. Seltzer, Phys. Rev., **C 2** (1970) 621.

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[11] "Fatigue and Durability of Structural Materials", S.S. Manson and G.R. Halford, ASM International, ISBN-10 # 0-87170-825-6.

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Budget Justification: Year 1

The first year will focus on performing positron production measurements in order to benchmark the simulation. Funds from this proposal will be used to support a research faculty member currently on staff at the Idaho Accelerator Center, Dr. Khalid Chouffani. Dr. Chouffani will perform these measurements along with a graduate thesis student and our JLab partners, Arne Freyberger and his graduate student Serkan Golge. A thesis student will be fully supported by this proposal. The PI, Dr. Tony Forest, and Co-PI, Dr. Alan Hunt will direct the research. Dr. Tony Forest brings his research experience using the CEBAF to the project and Dr. Hunt brings his experience in positron production. Idaho State University will provide release time to Dr. Forest in the amount of 10% annually and 5% for Dr. Hunt in order to oversee this project. Support in the amount of $20,000 is requested for a Graduate student. Graduate student tuition and health benefits are considered fringe benefits.

A Faraday cup, Model AC-3/FD-1 from Thermionics vacuum products, will be purchased at a cost of $6,000 and installed in order to normalize the measurements made at the Idaho Accelerator Center. A quote for the above Faraday cup was used to determine the above cost. Tungsten converter targets ($100 per target) and raw materials for the construction of the positron target proto-type will be acquired during the first year at an estimated cost of $7,000. This budget includes beamline materials for constructing the converter chamber, controls, and infrastructure for a target motor which will be purchased in year 2. The individual costs of each part falls below the $5,000 limit for being listed as equipment. A travel budget of $5,000, equivalent to 3 visits, will allow an exchange of personnel between JLab and the IAC in order to collaborate on the project as well as attend the annual EPSCoR program review/contractors meeting. The Idaho Accelerator Center will provide $15,000 of beam time per year as a **cost sharing** measure for this proposal. The above beam time cost match from the IAC of $15,000 per year corresponds to an 11% cost match. Faculty release time increases the level of matching funds from the required 11% to 20%.

Budget Justification: Year 2

The second year's activities will use the benchmarked simulation to determine the optimal positron source configuration. Salaries will be increased by 3% in order to offset cost of living increases. An increase of 10% is being assumed for insurance and 7% for tuition. A brushless servo motor will be purchased at a cost of \$15,000 which will be used to rotate the tungsten target in order to increase the average heat load the target can sustain. A materials and supply budget of \$495 is requested for the installation of the motor. A travel budget of \$5,000 will allow an exchange of personnel between JLab and the IAC in order to collaborate on the project as well as attend the annual EPSCoR program review/contractors meeting. The IAC will provide another **cost sharing** infusion of \$15,000 for beam time to perform heat load measurements and resolve unanswered questions from the previous year's comparison with the simulation.

Budget Justification: Year 3

The final year will measure the performance of the positron source, evaluate the extraneous radiation levels it generates and end with hosting a workshop on the implementation of the positron source at JLab. Salaries will be increased by 3% in order to offset cost of living increases. An increase of 10% is being assumed for insurance and 7% for tuition. The IAC will provide the final **cost sharing** installment of \$15,000 for beam time the measure the positron source performance. A travel budget of \$20,000 will allow an exchange of personnel between JLab and the IAC for the year, attendance at the annual EPSCoR program review/contractors meeting, as well as support the travel of several speakers to a JLab positron workshop hosted by the IAC. The travel expenses appear as foreign travel in order to invite international experts to the workshop. It is assumed that domestic travel may be paid from the foreign travel budget category without requesting permission from the granting agency.