Center for Neutrino Physics
Annual Report for FY 2013

October 1, 2013
I. Mission of the Center

The Center for Neutrino Physics (CNP) at Virginia Tech is an organization of faculty and students committed to continuing the growth and advancing the stature of the existing, highly visible neutrino science program at Virginia Tech. We are committed to fostering a dynamic environment that enthusiastically promotes the recruitment and education of high-quality students; actively initiates and conducts timely research at the interface of theory, experiment, nuclear, particle and astroparticle physics. VT-CNP will form the framework needed to compete for funding from programs such as the NSF’s Physics Frontier Centers (PFC) program, and to promote, by exploiting the obvious synergies, the continued growth of our efforts and funding through DOE and NSF programs.

In support of this mission, the objectives of CNP are to:

- Provide a unified image for the science program in neutrino physics and related fields at Virginia Tech through the use of an integrated organization structure, coordinated programs, common showcase facilities, and common outreach activities
- Act as a focal point to attract renowned scientists in visiting positions in order to enrich our activities
- Serve as a research engine for the University, aggressively seeking support for research projects from government and foundational sources
- Provide a flexible framework within which expertise can evolve or be added to meet important developing scientific or technological areas relevant to our research
- Attract and organize workshops and international conferences
- Hold a weekly seminar for the fields of high energy physics, nuclear physics and astrophysics, joint between theory and experiment
- Generate increased interest in our program by providing a unified appeal to potential sponsors, students and faculty candidates through purposeful public relations communications and promotion of our state-of-the-art facilities, research findings and capabilities
- Improve operational effectiveness through efficient use of funds, time and personnel

II. Classification of Institute and Organizational Structure

Center Director: Jonathan Link
Contact Person: Sharon Proffitt
Website URL: http://cnp.phys.vt.edu/

Faculty:
1. Patrick Huber – Neutrino Phenomenology
2. Jonathan Link (Director) – Neutrino Experiment (Daya Bay, LBNE, LENS-Sterile)
3. Bill Louis (Adjunct) – Neutrino Experiment (MiniBooNE, LBNE)
4. Camillo Mariani – Neutrino Experiment (MicoBooNE, Double Chooz, Hyper-K LBNE)
5. Djordje Minic – String Theory
6. Leo Piilonen – Particle Experiment (Belle, Belle II, Daya Bay)
7. Mark Pitt – Nuclear Experiment (Qweak, Møller, LENS)
8. Eric Sharpe – String Theory
9. Tatsu Takeuchi – Particle Theory
10. R. Bruce Vogelaar (KURF Director) – Neutrino Experiment (Borexino, LENS)

Research Personnel
1. Ufuk Aydemir – Post-doctoral Researcher
2. Pilar Coloma – Post-doctoral Researcher
3. Leonidas Kalousis – Post doctoral Researcher
4. Szymon Manecki – Post doctoral Researcher
5. Jo Ellen Morgan – Lab Specialist
6. Lazlo Papp – Lab Specialist
7. Derek Rountree – Post-doctoral Researcher
8. XiaoLong Wang – Post-doctoral Researcher

Graduate Students
1. David Bravo
2. Eric Christensen
3. Wade Duvall
4. Li Gui
5. Yuen-Keung “Joseph” Hor
6. Bei Jia
7. Yee Kao
8. Anna Lee
9. Zachary Lewis
10. Evan Guarnaccia
11. Patrick Jaffke
12. Yao Li
13. Yue Meng
14. Zachary Yokley
15. Kimberly Williams

Administrative Staff
1. Sharon Proffitt

III. Amendments to the Center Charter

None.

IV. Stakeholders Committee

The board of stakeholders will, in accordance with University rules, be comprised of representatives from the College of Science, the Department of Physics, and the Research Division. We propose the following members:

- Office of the VP of Research, for the Research Division – Robert Walters
- Dean of Science, for the College of Science – Lay Nam Chang
- Chair of Physics, for the Department of Physics – Leo Piilonen

The board of stakeholders will conduct reviews of the performance of the center and its director every five years. The performance criteria are laid out under the VT-CNP objectives.
V. Major Contracts Received in 2012-2013

Continuing Grants:

1. “Research in Geometry, string Compactifications and Mathematical String Theory,” funded by the National Science Foundation for $135,000 from 9/1/2011 to 8/31/2014. PI: Eric Sharpe
2. “Neutrinos in the Universe,” funded by the US Department of Science for $600,000 from 4/15/2010 to 4/14/2014. PI: Patrick Huber
3. “Study of Electroweak Interactions,” funded by the U.S. Department of Energy for $1,542,000 from 2/1/2010 to 1/31/2013. PI: Leo Piilonen and CoPIs: Jonathan Link, Djorde Minic and Tatsu Takeuchi
4. “Solar Neutrinos,” funded by the National Science Foundation for $921,000 from 9/15/2011 to 8/31/2014. PI: Bruce Vogelaar
5. “Subcontract for Work on Daya Bay,” funded by Brookhaven National Lab for $127,795 from 10/18/2011 to 12/31/2016. PI: Jonathan Link
6. “Strange Form Factors and Precision Standard Model Tests,” funded by the National Science Foundation for $270,000 from 8/15/2008 to 7/31/2012. PI: Mark Pitt
7. “Probing the Standard Model with Parity-Violating Electron Scattering,” funded by the National Science Foundation for $440,492 from 8/1/2011 to 9/30/2014. PI: Mark Pitt
8. “Collaborative Research: Mini-LENS – Operation of a prototype Low-Energy Solar Neutrino Spectrometer Underground,” funded by the National Science Foundation for $1,148,855 from 9/1/2010 to 8/31/2013. PI: Bruce Vogelaar and CoPIs: Mark Pitt and Jonathan Link
9. “Supplement to Work on Daya Bay,” funded by Brookhaven National Lab for $60,000 from 12/1/2011 to 12/31/2012. PI: Jonathan Link
11. “International Neutrino Summer School,” funded by the US Department of Energy for $25,000 and running from 6/1/2012 to 5/31/2013. PI: Patrick Huber
12. “International Neutrino Summer School,” funded by the National Science Foundation for $10,000 from 8/15/2012 to 7/31/2013. PI: Jonathan Link

New Funding Grants:

2. “Feasibility to Locate DIANA at KURF,” funded by the University of Notre Dame for $74,680 from 9/1/2012 to 8/31/2013. PI: Bruce Vogelaar
3. “US Belle II Project Phase II,” funded by the Pacific Northwest Laboratory for $125,000 from 7/26/2012 to 7/31/2013. PI: Leo Piilonen
4. “Graduate Student Research Assistant in Accelerator Physics at Jefferson Lab,” funded by the Southeastern Universities Research Association for $107,833 from 8/6/2013 to 8/5/2017. PI: Mark Pitt
Major Proposals Submitted or Pending

1. “Online Monitor system and proton decay R&D in MicroBooNE,” submitted to University Research Associates requesting $20,000. PI: Camillo Mariani
2. “Doubel Chooz reactor neutrino experiment,” submitted to the National Science Foundation requesting $110,802. PI: Camillo Mariani
3. “Study of proton decay, neutrino cross-sections and FSI in the MicroBooNE, experiment,” submitted to the US Department of Energy requesting $771,151. PI Camillo Mariani

VI. Significant Accomplishments in 2012-2013

CNP in the News:

1. PhysicsWorld, “Sterile-neutrino hunt gathers pace at Gran Sasso” (6/21/13)
2. Science Magazine, “Breakthrough of the Year: Crash Project Opens a Door in Neutrino Physics” (12/21/12)
3. New Scientist, “Neutrinos - the next big small thing” (9/10/12)

Center Related Events and Activities:

The International Neutrino Summer School
_Blackburg, Virginia, USA_
_July 10-21, 2012_

This annual event, held in the US once every three years, gathers experts from all areas of neutrino physics to lecture to graduate students and postdoctoral scientists. This year’s school brings approximately 80 students from 15 different countries and 14 lecturers to VT and provides an excellent educational opportunity for visiting students as well as the Center’s students. Center member Huber is co-chairing the organizing committee. In addition to CNP, INSS is being supported by, the US Department of Energy, the College of Science, the National Science Foundation, the Division of Research, Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory, The Sanford Underground Research Facility and the Physics Department.
Symposium on the Life and Science of Raju Raghavan
October 20, 2012
Blacksburg, VA, USA

Raju Raghavan had long been a leading figure in experimental neutrino physics, before his death on October 20th 2011. From his contributions to the study of solar neutrinos, and his seminal work on metal loaded scintillator, to his proposals to study geoneutrinos and of $^{51}$Cr as a low energy neutrino source, Raju's creativity, energy and intellect have helped to define the field as we know it today. This one day Symposium covered the full breadth of Raju's life in science, but also focused on Raju the man: his creativity, his infectious enthusiasm, his kindness and humanity.

nuSTORM Workshop
April 12-13, 2013
Blacksburg, VA, USA

This workshop, focused on the completion of the nuSTORM proposal to the Fermilab PAC. Participation is open to anyone considering being a part of the nuSTORM proposal, or interested in learning more about the proposal nuSTORM project.

Borexino Collaboration Meeting
May 3-4, 2013
Blacksburg, VA, USA

This meeting of the Borexino Collaboration was the first held at Virginia Tech and a rare instance of a Borexino Meeting to be held outside of Italy. More than 30 people attended the meeting. Discussions included the current status of the experiment, data analysis, future prospects, and the upcoming SOX source experiment program.

KURF User Meeting
June 7, 2013
Blacksburg, VA, USA

This first annual meeting of Kimbalton Underground Research Facility (KURF) Users was intended to highlight work currently going on at KURF and to discuss future efforts that may be undertaken at KURF. This meeting was open to all current KURF users, and anyone who is interested in low-background, underground science at KURF.
Belle Collaboration Meeting  
*July, 2013*  
*Blacksburg, VA, USA*

The quarterly Belle and Belle II collaboration meetings were held back-to-back at Virginia Tech in July 2013, with Belle's general meeting on July 1 and 2 and Belle II's general meeting on July 4-7. These meetings bring together the collaborators to discuss upcoming physics results (from Belle), to review progress and plans for the construction of the second-generation detector and accelerator (for Belle II), and to carry out collaboration-wide business meetings of the Institutional Boards, the Executive Boards, and the Financial Boards. Traditionally, these meetings have been held at the High Energy Accelerator Research Organization (KEK) in Japan where the experiments are located physically. Three years ago, both collaborations agreed to hold one set of joint meetings per year at a venue outside KEK. About 130 participants travelled to Virginia Tech for this meeting from the United States, Italy, Mexico, China, and Russia.

**Experimental Projects Involving Center Members:**

**Borexino – Gran Sasso National Lab, Italy**  
(Center Faculty: Vogelaar)  

The objective of the experiment is to measure the $^7$Be solar neutrino flux. This measurement will help us better understand the workings of the Sun, and also the masses and mixings of the neutrinos.

The Virginia Tech group designed and built the calibration and monitoring system and procedures used Borexino. This includes methods to manipulate and pin-point the location of radioactive sources for testing the internal detector.

**The Daya Bay Reactor Neutrino Experiment – Daya Bay Nuclear Power Station, China**  
(Center Faculty: Huber, Link and Piilonen)  

The Daya Bay Reactor Neutrino Experiment was designed to search for neutrino oscillations mediated by the mixing angle $\theta_{13}$. Daya Bay uses electron antineutrinos produced in the cores of the 6 nuclear reactor at the site. $\theta_{13}$ is the key to determining if neutrinos played a crucial role in generating the large matter-antimatter asymmetry the universe.

The Virginia Tech group designed and built the calibration system for the muon water pool and the high voltage system for the Resistive Plate Chambers.

**Double Chooz Reactor Neutrino Experiment – Chooz, France**  
(Center Faculty: Mariani)  

The Double Chooz experiment was also designed to search for $\theta_{13}$ using antineutrinos from nuclear reactors. It continues to take data and is preparing to install its near detector.
Future Neutrino Physics Experiments and R&D Projects:

**Low Energy Neutrino Spectroscopy (LENS) – KURF, Virginia**  
(Center Faculty: Vogelaar, spokesman)

The objective of the LENS experiment is to measure the entire solar neutrino energy spectrum to high accuracy. Water Cherenkov detectors, such as Super-Kamiokande and SNO, can only measure the high-energy Boron 8 neutrinos which comprise less than 1% of the total solar neutrino flux. LENS uses Indium doped Liquid Scintillator technology which allows it to capture over 99% of the solar neutrinos including the low-energy $pp$ neutrinos.

**Source Oscillations with BoreXino (SOX)**  
(Center Faculty: Link, Vogelaar)

The SOX experiment is a follow up to the Borexino experiment in which a $^{51}\text{Cr}$ radioactive neutrino source will be brought to the detector and used in a search for sterile neutrino oscillations. Virginia Tech is working with Oak Ridge National Lab to make and deliver the source.

**Long Baseline Neutrino Experiment (LBNE) – Fermilab, Illinois to South Dakota**  
(Center Faculty: Link and Mariani)

LBNE is a proposed experiment designed to measure the CP violating phase in the neutrino mixing matrix and to determine the ordering of the neutrino mass eigenstates, or the neutrino mass hierarchy. A beam of muon neutrinos will be send from Fermilab in Illinois to a detector in South Dakota. The experiment will count the rate of electron neutrinos that appear in the beam and compare that rate to the rate of electron neutrinos observed in a smaller detector on the Fermilab campus.

**Oscillations at the Spallation Neutron Source (OscSNS) – ORNL, Tennessee**  
(Center Faculty: Link and Louis, spokesman)

OscSNS is a proposed experiment to conduct a direct test of the LSND oscillation signal with neutrinos from the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory. The SNS is designed to produce neutrons for a wide range of experiments in basic energy sciences, but it also is a massive source of neutrinos from the decay of $\pi^+$ particles produced and brought to rest in the SNS target (the same mechanism used to make neutrinos for LSND). CNP member Bill Louis is leading this proposal effort.

**Neutrinos from Stored Muons (νSTORM) – Fermilab, Illinois**  
(Center Faculty: Huber, Link and Mariani)

νSTORM is a proposed facility at the Fermi National Accelerator Laboratory which would create an entry level neutrino factory. In addition to being a test bed for neutrino factory and muon collider technology, νSTORM’s neutrino beams would be used to study short baseline neutrino
oscillations with the golden mode muon neutrino appearance channel, and to make the first ever measurement of electron neutrino cross sections at accelerator energies.

In FY2013 proposals were submitted to both Fermilab and CERN. The project received stage-1 approval at Fermilab and was encouraged by CERN.

**Other Nuclear Physics Experiments:**

**Qweak – Jefferson Lab, Virginia**  
(Center Faculty: Pitt)

The objective of this experiment is to measure the weak charge of the proton, \(Q_p^w\), i.e. its coupling strength to the \(Z\) boson, to very high accuracy. The weak charge of the proton is predicted by the Standard Model to be \(Q_p^w = 1 - 4 \sin^2 \theta_W\), where \(\sin^2 \theta_W\) is a quantity that has already been measured accurately at LEP and SLD. Any deviation of Qweak's measurement of \(Q_p^w\) from the Standard Model prediction will be a signal of new physics.

**G-zero – Jefferson Lab, Newport News, Virginia**  
(Center Faculty: Pitt)

The goal of the GØ experiment is to learn more about the quark substructure of protons and neutrons (nucleons). Our interest is in the distributions of charge and magnetization in the nucleon and how it is built up out of the different types of quarks. We are particularly interested in whether these distributions have any contribution from strange quarks as this type exists only "virtually" in nucleons as the result of the quantum mechanical interplay between mass and energy.

**Other Particle Physics Experiments:**

**Belle – KEK, Tsukuba, Japan**  
(Center Faculty: Piilonen, co-spokesperson)

The Belle Experiment studies the properties of the beauty (\(b\)) quark. The \(b\) quark is produced in pairs with the anti-\(b\) quark at the KEKB \(e^+e^-\) asymmetric collider. The Belle experiment studies the decay patterns of the \(b\)-quark to search for clues on how our universe is constructed.

Leo Piilonen was elected co-spokesperson of the Belle collaboration for a two-year term beginning on April 25, 2012.

**Belle II-KEK, Tsukuba, Japan**  
(Center Faculty: Piilonen)

Following up on the success of the Belle Experiment, Belle II aims to continue studying the properties of the \(b\)-quark with increased luminosity. The upgrade of the KEKB accelerator, which is expected to take 3 to 4 years, has been approved by the Japanese government. Improvements to the Belle detector design are currently under intense study.
Publications by Center Members:

26. “Evidence for the $\eta_b(2S)$ and observation of $h_b(1P) \to \eta_b(1S)\gamma$ and $h_b(2P) \to \eta_b(1S)\gamma$,” the Belle Collaboration [R. Mizuk, et al.], Phys. Rev. Lett. 109, 232002 (2012).
30. “Search for the decay $B^0 \to DK^*0$ followed by $D \to K^0\pi^+$,” the Belle Collaboration [K. Negishi, et al.], Phys. Rev. D86, 011101 (2012).

Other Significant Accomplishments

1. The Q-weak Collaboration with Mark Pitt as analysis coordinator will publish their first major results in a paper titled, “First Determination of the Weak Charge of the Proton,” in Physical Review Letters on October 18, 2013.
2. Leo Piilonen, of the Center for Neutrino Physics, was elected as one of the spokespersons of the Belle Collaboration. As spokesperson, Prof. Piilonen helped guide the collaboration as they undertook the major upgrade of experiment to Belle II.
### VII. Report on Financial Condition

#### Center Financial Report Fiscal Year 2013

<table>
<thead>
<tr>
<th>Account</th>
<th>Starting Balance</th>
<th>Income</th>
<th>Expenses</th>
<th>Ending Balance</th>
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<td><strong>Operations Account (118753)</strong></td>
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<td>A21 Award</td>
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<td>INSS 2012 (Phys Contributions)</td>
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<td>Tom Shea (COS and ME Contributions)</td>
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<td>Salary for Sharon Proffitt</td>
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<td>Science Project Support</td>
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<td>Miscellaneous and Supplies</td>
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<td>Miscellaneous $242</td>
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| **Overhead Account (234003)** | $54,381          |              |                               |                |
| Starting Balance              |                  | $31,960      | Overhead Earnings $16,000      | $41,227        |
| Speaker Support               |                  | $17,252      | School Support $10,819        |                |
| INSS 2012 Support             |                  | $25,000      | Visitor Program $5,000        |                |
| Salary for Sharon Proffitt    |                  | $2,150       | Phone Conferencing $1,500     |                |
| Phone Conferencing            |                  | $470         | Miscellaneous $250            |                |
| Miscellaneous                 |                  | $242         | **Ending Balance** $40,658    |                |

| **CPE Surplus Account (564910)** | $2,552            |              |                               |                |
| Starting Balance               |                  | $0           | INSS Surplus $17,720          |                |
| INSS Support                   |                  | $984         | **Belle Meeting Support (and Pass Through)** $8,000 |                |
| Science Project Support        |                  | $796         | Science Project Support $5,000 |                |
| Miscellaneous                  |                  | $56          | **Ending Balance** $7,272     |                |
| **Ending Balance**             |                  |              |                               | $716           |

#### Center Financial Projection Fiscal Year 2014

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<th>Expenses</th>
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<td><strong>Operations Account (118753)</strong></td>
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<td><strong>Ending Balance</strong> $0</td>
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</table>

| **Overhead Account (234003)** | $41,227          |              |                               |                |
| Starting Balance              |                  | $33,000      | Overhead Earnings $16,000      | $40,658        |
| Speaker Support               |                  | $16,000      | School Support $10,819        |                |
| INSS 2012 Support             |                  | $25,000      | Visitor Program $5,000        |                |
| Salary for Sharon Proffitt    |                  | $10,819      | Phone Conferencing $1,500     |                |
| Phone Conferencing            |                  | $5,000       | Miscellaneous $250            |                |
| **Ending Balance**            |                  |              | **Ending Balance** $40,658    |                |

| **CPE Surplus Account (564910)** | $7,272            |              |                               |                |
| Starting Balance               |                  | $17,720      | INSS Surplus $17,720          |                |
| **Belle Meeting Support (and Pass Through)** | $8,000       |              | Science Project Support $5,000 |                |
| **Ending Balance**             |                  |              | **Ending Balance** $7,272     |                |

Total Starting Balance: $70,952
Total Ending Balance: $48,081

Total Starting Balance: $49,917
Total Ending Balance: $47,931
### FIN_SNAP_BY_CRZN (V6)

**Virginia Tech - Warehouse PROD**

Banner Finance System: Snapshot by Organization

Fiscal Year 2013 thru the period ended 30-JUN-2013

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**Total Expenditures Center for Neutrino Physics**

| 4,256,552.42 | 4,359,764.96 | 188,765.00 | 2,120,245.92 | 55,254.00 | 2,184,221.04 | 49.50 |

Center for Neutrino Physics
VIII. Major Issues of the Center

In FY14, the center will continue its very successful seminar speaker’s series. We are hosting two long term visitors: Omar Benhar from Università degli Studi di Roma "La Sapienza" in Italy and Yongjoon Kwon from Yonsei University in Korea. We continue to pursue, and in some cases lead experimental proposals and projects for short baseline oscillation searches including: MicroBooNE, OscSNS, nuSTORM and SOX. In the coming year we will submit major new proposals to fund the SOX and LENS programs. Prof. Huber will take part in a major proposal to the National Nuclear Security Administration on nuclear non-proliferation. Lara Anderson and James Gray, working in sting theory, were hired into the Physics Department from a search in the 2012-2013 academic year have joined CNP.