



University of Virginia Physics News

Volume 4, Number 2

Fall 2012

Letter from the Chair

Dear Alumni & Friends,

First I wanted to take this opportunity to wish everyone the best for the upcoming holidays. As always, your continued support of the teaching, research, and outreach efforts of the Department is appreciated and remembered.

Our university leaders are in the process of strategic planning for the future of the University, given the state's base budget reduction and the expected cutback in federal funding. Although we cannot predict the future in these uncertain times, I believe that as a faculty and as a community, we should keep our focus on our core mission of education and research. In this past fiscal year, the external research funding of the Department is again ahead of the other science departments in the College. We see an increasing number of students continue to choose to study physics, both because the subject is interesting, and because the problem-solving skill they learn enables them to consider many career paths. This Fall, the entering class of 23 graduate students is the largest in recent years. Our research groups are looking forward to having them as colleagues. We will continue to work hard to improve the quality of education and training at the graduate level.

This year, the biggest news in physics is undoubtedly the discovery of the Higgs-like particle at the Large Hadron Collider in CERN. The UVa experimental high energy physics team and its significant roles in the discovery of the decade are featured on pages 2 and 3 of this newsletter. In particular, congratulations to Professor Brad Cox, the team leader, and his colleagues for a job well done and for the recognition they have brought to our Department. I hope you will enjoy reading the article.

Joseph Poon

Thank You!

We greatly appreciate your continued support of the Deaver Scholarship Fund, general pledges and new initiatives. For additional information, please contact:

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New Faculty

Utpal Chatterjee joined us this Fall as an Assistant Professor of Experimental Condensed Matter Physics.

Honors and Awards

Undergraduate Students

The Mitchell Scholars for 2012 were **Peter Breiding**, **David van Petten**, and **Anthony Charles**.

The Most Outstanding Physics Major Award went to **Aaron Thomas Criss**, **Kridsanaphong Limtragool** and **Voravit Vorapipat** in 2012.

Olivia Paule Sullivan won the 2012 Stephen T. Thornton Outstanding Undergraduate Physics Research Award, for her work, "The Impact of Injected Dose on Image Quality of Molecular Breast Imaging Tomosynthesis", supervised by Mark Williams.

Ryan A. Loomis won the 2012 Presidential Research Poster Competition.

Graduate Students

Kosta Popović won the 2012 Presidential Research Poster Competition.

In the Spring 2012 Graduate Poster Competition, First Place was awarded to **Jooseop Lee**, Second Place to **Anthony Palladino**, Third Place to **Hyunwook Park**, Fourth Place to **Sachith Dissanayake**, and Honorable Mention to **Mandy Gu**. All the posters are online at www.phys.virginia.edu/Research/GraduatePosters/Spring2012.

Rachel Yohay won the US LHC Users Organization Award for her contribution to the CMS experiment. (Five of the 861 students working on the Higgs discovery project were recognized for special achievement.)

Please send address changes, comments, and suggestions about the newsletter to

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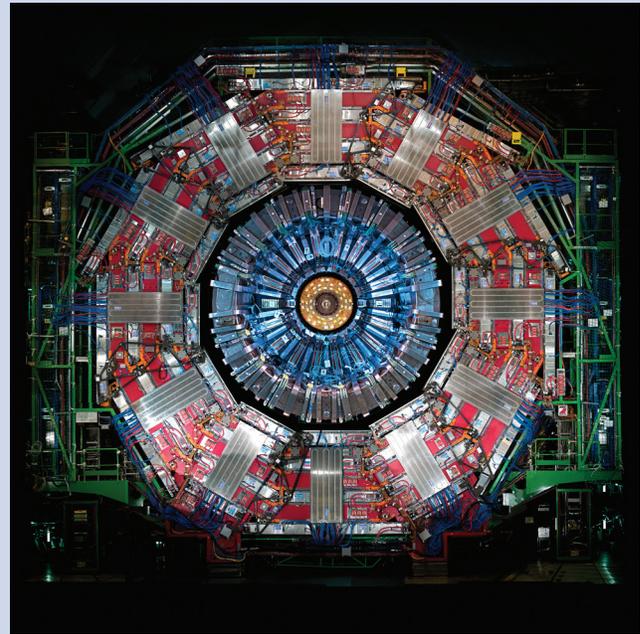
The Discovery of the Higgs Particle

At 3:00 AM EDT on July 4th, the Compact Muon Solenoid (CMS) group at UVa joined thousands of their collaborators all over the world to celebrate the announcement made at CERN, near Geneva, of the discovery of a new particle that appears to be the long sought after Higgs boson. For over 50 years since it was hypothesized by Peter Higgs and others, searches at a succession of accelerators have closed in to the range where this particle could be. Now a 125 GeV mass object that appears to fit the characteristics of a Higgs boson has been detected by the CMS and ATLAS experiments at the Large Hadron Collider at CERN. The UVa group has been involved in this search in important ways.

Professor Brad Cox, the team leader, stated to the press that “this is a profound discovery, more significant in some respects than the fleshing out of the table of fundamental particles by the discoveries of leptons, quarks, and vector bosons, that have happened during the last 50 years. The Higgs scalar field, that gives mass to all other particles, is the central lynchpin of the framework we call the Standard Model (SM). The particle that has been discovered at CERN must pass several other tests before it can be determined if it is a SM Higgs boson or one of several Higgs bosons. In any case, the observation of this object leads to expectations that there are large numbers of additional particles in a system like Supersymmetry (SUSY) waiting for future detection. This is just the first layer of the onion.”

The UVa CMS group members have been very active in the effort to find the Higgs boson. During the last few years, the group included three faculty (B. Cox, C. Neu, and R. Hirosky), an emeritus faculty member (S. Conetti), two research scientists (A. Ledovskoy, M. Arenton), a postdoc (S. Boutle), and eight graduate students (D. Andelin, M. Balazs, J. Goodell, C. Lin, D. Phillips, R. Yohay, E. Wolf, and J. Wood). M. Balazs and R. Yohay have already taken their PhDs in the CMS experiment.

While this is a large experiment, a university group can have a major impact. This is the case with the UVa CMS group. They participated in the preparation, installation, commissioning, and operation of the Electromagnetic detector of CMS (ECAL), which was the most important subdetector used in the detection of the Higgs. In particular, they designed, installed and operated light source calibration systems for 14,468 of the detector elements of the



CMS detector cross-section. Image courtesy of CERN (<http://cdsweb.cern.ch/record/1474902>).

ECAL. Group members had important managerial roles in the preparation of the ECAL with Cox serving as the CMS Electromagnetic Detector manager for the United States, and Ledovskoy, among other roles, serving as operations co-manager for part of the ECAL.

As well as active participation in the building of the detector, the group took an active role in the physics analyses. The faculty participated and led physics analyses in Supersymmetry (Cox), Top and Higgs (Neu), and prompt photon production (Hirosky). Finally, members of the group have served as conveners, editors, and on analysis review committees (ARCs) that oversee the progress of various analyses and give the authorization for the analyses to go forward for publication. Indeed, Cox served on several ARCs whose responsibility over the last two years was to monitor and review the progress of the most important Higgs analyses to render judgment on readiness to go public with the discovery. According to Professor Cox, “The discovery of a Higgs boson is truly a profound event in the history of physics. All the CMS participants get a championship ring.”



Thomas Anderson

Mike Arenton

Sarah Boutle

Joey Goodell

Brian Francis

Sasha Ledovskoy

Chuanzhe Lin

David Phillips

Cox Leads UVa CMS Team

Professor Brad Cox, the leader of the UVa Compact Muon Solenoid (CMS) team, has been involved in many experiments at Brookhaven National Laboratory, Stanford Linear Accelerator Center, Fermi National Accelerator Laboratory and CERN. He did pioneering work on quark-quark and quark-gluon direct photon production, studied heavy flavor production, and performed time reversal violation measurements. Professor Cox has acted as scientific spokesman for several of these experiments. He was a professor at Johns Hopkins University and Fermi National Accelerator Laboratory before joining the University of Virginia faculty to found the experimental particle physics group. While at Fermilab he served as head of the Proton Laboratory and the Research Services Department and was deputy chair of the Physics Department. During his tenure as head, the b quark was discovered at the Proton Lab.

Professor Cox has recently been engaged in studies of the very basic structure of matter and the evolution of the universe in the CMS experiment at CERN in Geneva, Switzerland. This experiment will be at the forefront of experimental particle physics for the next few decades and has recently discovered what appears to be the Higgs particle. Recently Professor Cox was part of a four-person review committee on CMS charged with verifying that the most important aspect of this discovery was valid. His future plans are to try to detect supersymmetric particles in the CMS experiment in a search for the origin of dark matter in the universe. In his role as the United States manager of the CMS electromagnetic detector effort, Professor Cox is responsible for the operational activities and budgets of eight US universities working on the EM detector. He also serves as co-leader of the CMS Forward Calorimetry Upgrade Task Force charged with conceptual design of calorimetry capable of withstanding high radiation levels and rates in the High Intensity LHC era.



New Faculty Spotlight

Utpal Chatterjee

Utpal Chatterjee joined the department this fall. Before coming to UVa he was at the Materials Science Division of the Argonne National Laboratory where he was a postdoctoral researcher with a Director's Fellowship. He moved to Argonne after finishing his PhD at the University of Illinois at Chicago.

He works in experimental condensed matter physics with primary emphasis on studying electronic and magnetic properties of complex materials in which exotic quantum states emerge due to the collective dynamics of a very large number of electrons. To investigate such correlated electron systems, he employs an advanced experimental probe, known as Angle Resolved Photoemission Spectroscopy (ARPES). In an ARPES experiment, a photon strikes a solid, from which an electron is ejected as a consequence. Using modern electrostatic analyzers, energy and momentum of the ejected electron are simultaneously measured and from such measurements one can directly obtain the information on the electronic band structure of the solid. Such information is crucial to understand almost all the physical properties in those materials—ranging from their colors to their electrical conductivities.

In his recent research activities on high temperature superconductors, a class of materials that conduct electricity without resistance at relatively high temperatures, he has made significant contributions to the understanding of the enigmatic pseudogap phase which supposedly holds the key towards the realization of a microscopic theory for these materials. In one of his published works, he constructed a generic phase diagram for these materials which clearly exhibits the evolution of superconductivity from the so called “strange metal phase”. In another work, he demonstrates the first ever spectroscopic signature of a nodal liquid in $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ high temperature superconductors, a unique state of matter that exists only at four isolated points in the momentum space. His current research programs focus on spectroscopic study of a wide range of physical systems, which include different nanoscale materials, oxide interfaces and topological insulators.

Here at UVa, he is currently building a novel laboratory-based ARPES experimental setup, which will accompany unique capability to alter properties of materials in situ, via pressure and electric field. He is also exploring the possibility of incorporating laser-based photon sources to this instrument, which will allow performing ARPES experiments with higher bulk sensitivity as well as time resolved studies of electron dynamics in the sub-picosecond regime.



Chris Neu

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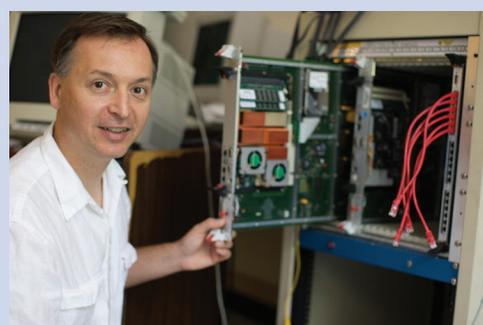
Faculty Profile: Bob Hirosky

Professor Bob Hirosky works at the energy frontier of High Energy Particle Physics using the world's most powerful particle colliders. He is an active member of two leading research teams: the Compact Muon Solenoid Collaboration (CMS) at CERN's Large Hadron Collider and the D-Zero Collaboration (D0) at Fermi National Accelerator Laboratory's (Fermilab) Tevatron accelerator. Bob's career in physics began with detailed studies of calorimeter detectors used to precisely measure

the debris formed in proton on anti-proton collisions at the Tevatron and to reconstruct the interactions taking place at distances of one-billionth-of-one-billionth of a meter, setting world records for precision measurements of the quarks and gluons that combine to form protons, neutrons, and other forms of subatomic matter.

His later efforts included building and managing the operation of a real-time "trigger" system for D0, designed to analyze the flowing data in real-time and to make mission-critical decisions about which data to retain for further analysis by the D0 team of more than 600 students and scientists. Given that interesting things pop out rarely and the high volume of data flowing through detectors at the colliders is enough to completely fill up your fancy cell phone 1000s of times every second, most data must be discarded instantly. When you are searching for figurative needles in a haystack, you'd better be very careful about the 99.999% of the pile you throw away!

Bob's physics interests have also focused on searches for the Higgs boson (see accompanying article in this is-



Bob Hirosky shows off some trigger electronics. Photo courtesy of Dan Addison/U.Va. Office of Public Affairs.

sue), where teams at the Tevatron have recently reported first hints of a new particle disintegrating into quarks. This evidence complements the discovery announced from the CERN experiments and gives an independent handle to examine this exciting new discovery.

Bob is currently serving in a prominent role as Physics Coordinator for D0, with responsibility of overseeing the scientific content for all physics results produced by the collaboration, leading to some 200

international conference presentations and 50 journal publications yearly. He is a recent recipient of a Universities Research Association Visiting Scholars Fellowship and has been an invited visitor at Fermilab numerous times during his tenure at UVa. Not content to work in only two time zones, Bob's research on the CMS experiment includes new measurements involving quarks and photons, development of electronics for the present and future detector, and R&D for future particle detectors.

Bob's team includes grad students Chuanzhe Lin (CMS), Huong Nguyen (D0), and postdoc Hengne Lin (CMS/D0). His students have won multiple awards and competitive admissions to international research programs and recent postdocs Mike Mulhearn (UC Davis) and Marc Buehler (Fermilab) have earned highly coveted positions in the field. Eager students are invited to come see the world, build amazing machines, and smash plenty of protons to find what new surprises await!