Department of Physics and Astronomy

The University of Tennessee

Academic Program Review

Self-Study Document

2015

Report prepared: December 2014

Review: February 2-4, 2015

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Preamble

The Department of Physics and Astronomy is a large and complex department within the College of Arts and Sciences at The University of Tennessee, Knoxville (UT). We employ more than 200 people with more than $13.5M flowing through over 100 departmental accounts. Comparing nationally, we have a fairly small, but distinguished, faculty with 33 tenure-line professors or 27.4 active FTE. These include four Fellows of the AAAS and 10 Fellows of the American Physical Society. The faculty constitutes the core of the department's vibrant and well-funded research program in key areas such as biophysics, computational astrophysics, condensed matter physics, nuclear physics, and high-energy particle physics. Our faculty publishes close to 275 papers each year in peer reviewed journals. Together with our two part-time lecturers, they teach almost 2500 students in our classrooms each fall, producing close to 8000 student credit hours.

Research expenditures have averaged close to $9M over the past four years, which is about 22 percent of the College's total research expenditures. The department recently lost key, award-winning faculty to other institutions and retirements; and as a result, lost several large research contracts. We have adjusted our strategic plan accordingly to prioritize toward restoration and future growth.

We continue to benefit from strong collaborative ties with Oak Ridge National Laboratory (ORNL). The department includes more than 30 research and adjunct faculty members, many of them from the national laboratory, who contribute substantially to our research portfolio and provide research opportunities for our graduate students. Through the ORNL connection and the associated UT/ORNL Joint Institutes, faculty and students have access to the most powerful computing resources and most intense neutron sources in the world.

The graduate program constitutes the pride of the department. With an average of 110 graduate students per academic year, the program is fairly large. Approximately 60 percent of the grad students are fully supported by external grants. The department typically graduates 20 students each year with about 2/3 of the graduates receiving a Ph.D. and 1/3 an MS degree.

The undergraduate enrollment has increased substantially since the 2005 Academic Program Review. We now have a healthy undergraduate program with about 100 physics majors. Graduation rates have almost doubled over the last decade with more physics majors participating in research. Our undergraduate enrollment in service courses for life science majors continues to rise at an extraordinary pace, which is putting our instructional capability in terms of both people and space under sever duress. We are offering the physics for life sciences courses out of sequence to promote the University's goal of graduation in four years.

As mentioned above, we have adjusted to our strategic plan to focus on departmental and university goals. This has resulted in the very positive development of successfully recruiting seven junior and one senior faculty within in the past four years while two more faculty searches are underway. In addition, we have made some very successful staff hires, which further professionalized departmental operations.

In the final chapter of this review document, we will highlight some of the challenges and opportunities that lie ahead in the context of upcoming retirements, the recently updated strategic plan, and the university's ambition of becoming a top 25 public university.

I. Mission and Background

A. Mission Statement

The mission of the Department of Physics and Astronomy is the foundation upon which all our strategic plan is built, as well as, most of our day-to-day operations. The mission statement reads:

The mission of The University of Tennessee Department of Physics and Astronomy is to promote and achieve academic excellence and scholarship in physics and astronomy, with synergistic undergraduate and graduate educational programs in teaching, research, and public service for the benefit of the State of Tennessee and the nation. The department seeks academic excellence with pedagogically sound and accepted methods of teaching using modern instructional technology, teaching materials, and equipment, and by involving its experienced and distinguished faculty at all levels of instruction, including general education and professional service courses. The department seeks excellence in research with a diverse faculty and staff in a well-balanced program with special emphasis in a limited number of strong concentrations led by nationally and internationally recognized researchers, well balanced between theory and experiment. It seeks excellence in public service by involving staff with professional organizations and with outreach programs for public and private educational institutions and the public at large.

The Department of Physics is strongly committed to supporting the Land-Grant mission of University of Tennessee by actively recruiting and educating undergraduate and graduate students from the state of Tennessee, by engaging in collaborations and partnerships with local industry, by carrying out a very active outreach program in Physics and Astronomy, and by carrying out a nationally recognized research program that enhances the intellectual and creative environment in Tennessee.

B. Commitment to VOL Vision

Our strategic plan is fully aligned with Vol Vision, the university's strategic plan. We support efforts aimed to advance UT toward peers on nationally tracked measures. To this end, we pay attention to activities that will be recognized by a consistently improved departmental ranking in external assessments. We are committed to continually improving the resource base to achieve campus priorities by carefully balancing state revenues, tuition, and private funding, and by embracing stewardship of our campus infrastructure and a culture that values sustainability. Our vision expressed by the mission statement can be best illustrated with a set of guiding principles for daily operation and strategic planning. They can be found in our strategic plan and in the Appendix.

C. Strategic Plan

The department has a long tradition of creating strategic plans to guide its future development. A plan was developed at the time of the previous program review in AY 2005/2006 and included a set of recommendations for areas of future hires. Several of the recommendations were implemented and some opportunity appointments – not envisioned in the plan – were made. Since the 2005/2006 program review, the research environment and educational landscape of our department have changed quite substantially. In particular, the rapid development of the UT/ORNL interactions within the Joint Institutes, additional State of Tennessee funds for hiring new Governor's Chairs, establishment of new Centers such as CIRE (UT/ORNL Center for Interdisciplinary Research and

Graduate Education) and NIMBioS (National Institute for Mathematical and Biological Synthesis), as well as other opportunities, had rendered the 2006 strategic plan out of touch with the new realities.

To enhance the quality and competitiveness of our department, assess new opportunities, and demonstrate our long-term vision, the planning committee decided in 2010 to develop a new strategic plan with input from the full faculty. The plan was developed based on principles consistent with the university's Top 25 and VOL Vision strategic plans and was approved by the voting faculty in February 2012. This strategic plan was again updated last fall with hiring recommendations for the upcoming five years. The update was necessary, as the hiring goals of the 2012 Strategic Plan will already be met at the end of AY14/15. The full faculty was asked once again to provide input, and the planning committee proposed new hiring priorities. The Strategic Plan update was discussed and approved by the faculty in November 2014. The 2012 Strategic Plan and 2014 strategic plan update can be found at http://www.phys.utk.edu/committees.html. The updated plan is also included in the Appendix.

D. History and Background

The detailed account of the history of the physics department, dating to the 1800's, can be found on the departmental website at http://www.phys.utk.edu/department/history.html. Historically, the most relevant feature of our department has been the strong emphasis on collaboration with ORNL. This mutual dependence goes all the way back to the early years after the Second World War, when the department started its graduate program primarily to provide MS and PhD degrees to scientists in Oak Ridge who had their education at other institutions disrupted by being transferred to Oak Ridge as part of the Manhattan Project. The first PhD from our department was awarded in 1950 to Ray Murray, who had been transferred in 1943 from Berkeley in the middle of his graduate studies. Dr. Murray later became one of the leading nuclear engineers in the United States and was the recipient of one of our first two Outstanding Alumni Awards. The history of the collaboration with ORNL is too long to describe here and the interested reader is referred to a 1998 article in our newsletter, *Cross Sections*: http://www.phys.utk.edu/xsections/cross4.htm.

The Distinguished Scientist (DS) and Joint Faculty (JF) programs with ORNL have had the most impact on the stature and faculty profile of our department. The DS program has allowed UT and ORNL to jointly hire some of the best scientists in the nation with the purpose of letting them spearhead expansion in their field at UT/ORNL. Gerald Mahan was the first DS to arrive in 1984 and was followed by Joe Macek (1988), Ward Plummer (1992), and Elbio Dagotto (2004). The strong growth of the size and quality of our condensed matter program can, to a very large extent, be attributed to Mahan's and Plummer's strong push for excellence in their field. Both Mahan and Plummer were elected to the National Academy of Sciences while at UT, but they unfortunately left in 2000 and 2008, respectively. The DS program has since been replaced by the Governor's Chair program. Unfortunately, the department has not been able to bring in new Governor's Chairs, not because of a lack of effort or availability of highly qualified candidates willing to move to Tennessee, but primarily because of different programmatic considerations by ORNL.

The UT/ORNL Joint Faculty program has allowed the department to hire many joint professors since 1989, when Ted Barnes came to UT/ORNL as a result of the efforts of one of our former distinguished scientists, Frank Close. This program has enabled us to hire outstanding new faculty with split appointments, even in tight fiscal situations, since the cost to UT is typically only half of what a full UT position would cost. Historically, about half of the joint faculty had a tenure-line appointment at UT-Physics (JFU) with the other half were based at ORNL (JFO). However, in recent years, several of these hard money appointments were lost due to attrition and retirements. Currently, the department has eight JFUs and two JFOs. For all practical purposes, JFUs and JFOs have the same privileges and

obligations as regular faculty with the exception that JFOs cannot vote on personnel matters such as tenure and promotion. In addition, the department now has a large number of soft money JFOs with variable appointments. These JFOs have no teaching responsibilities, and their obligations and privileges are similar to those of research or adjunct faculty. It is expected that they support the UT percentage of their appointment via external research contracts.

The UT/ORNL Joint Institutes constitute the core of the UT/ORNL collaboration. These interdisciplinary research centers of excellence aim to foster joint research activities and establish critical mass for landing big proposals. The physics department was instrumental in the creation of the first joint institute, back in 1984. This Joint Institute for Heavy Ion Research (JIHIR) has been a highly successful endeavor that enabled our nuclear physics program to flourish. The success of JIHIR led to the creation of several much larger and more ambitious joint institutes, namely the Joint Institute for Computational Sciences (JICS), Joint Institute for Neutron Sciences (JINS), Joint Institute for Advanced Materials (JIAM), and the Joint Institute for Biological Sciences (JIBS). All of the joint institutes, except for JIAM, are located at ORNL. JIAM affiliates, including our condensed matter faculty, will soon move into a brand new 144,000 square-foot research facility across the river on the new Cherokee campus. Our faculty has always played prominent leadership roles in the joint institutes. Professor Robert Grzywacz is currently Director of the Joint institute for Nuclear Physics and Applications (JINPA, which is the successor of JIHIR). Professor Tony Mezzacappa serves as Director of JICS while JIAM is co-directed by Professor Hanno Weitering.

Clearly, the department has benefitted tremendously from its proximity and strategic alignment with ORNL. However, changes in strategic priorities and unilateral personnel decisions at ORNL in the past 10 years painfully exposed our vulnerability in being too dependent on a research organization that is many times bigger than UT's combined research enterprise. These actions clearly contributed to the loss of key faculty and accessible infrastructure. While it is important to nurture mutually beneficial interactions with ORNL, it is also very clear that we must expand our own independent research portfolio and strive for excellence while achieving international recognition of our campus-based research. This can be done, for instance, by hiring regular nine-month faculty who are strongly committed the building research infrastructure on campus. This has now become a guiding principle for our strategic planning.

E. Program Administration

The department's management structure is outlined in the diagram below. The department head oversees key administrative issues in consultation with two associate heads. Support staff is responsible for various administrative, personnel, accounting, communications, instrument fabrication, computing, and outreach efforts. The faculty plays a fundamental role in the decision-making process, through faculty meeting votes, as well as collective contributions on committees, particularly the planning committee. The faculty develops departmental policies and strategies and also oversees faculty promotion and tenure, curriculum issues, student matters, teaching, outreach, and development. Student and staff representatives are included where appropriate. The department also has directors for the graduate and undergraduate programs as well as the undergraduate teaching laboratories to manage these critical responsibilities.

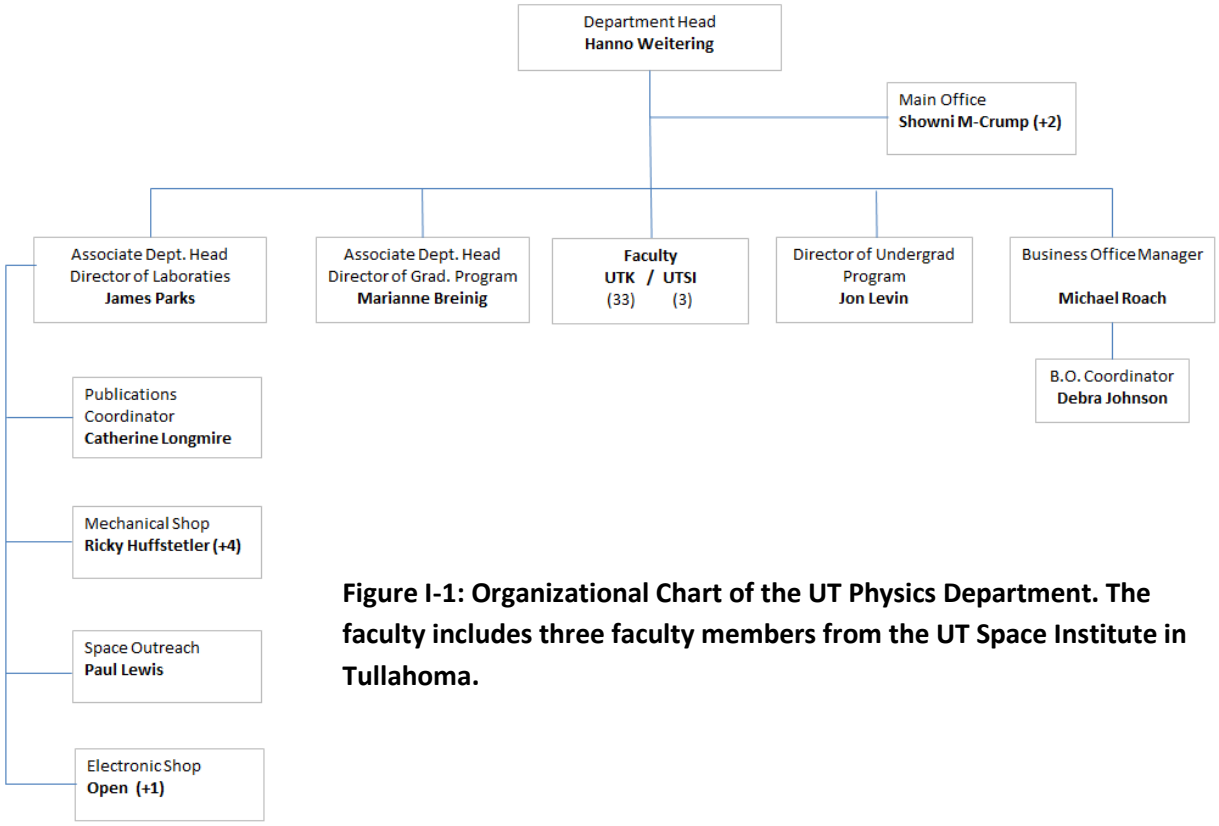

Figure I-1: Organizational Chart of the UT Physics Department. The faculty includes three faculty members from the UT Space Institute in Tullahoma.

Standing committees, along with ad-hoc committees, are used to govern all major decisions of strategic importance. For example, hiring priorities or initiation of searches, are first discussed within the planning committee then brought before the faculty for voting. We also have strong and active graduate and undergraduate committees for programs and curricula, along with a promotion, tenure, and awards committee consisting of four or five of our most respected professors. A complete list of all committees, their area of responsibility, and membership can be found in the Appendix or viewed online at http://www.phys.utk.edu/Assignments/ 2014-2015-areas-of-responsibility.htm.

The physics department at the UT Space Institute (UTSI) is an integral part of our department. UTSI is a graduate education and research institution located in Middle Tennessee, adjacent to the U.S. Air Force Arnold Engineering Development Center (AEDC). In accordance with its mission, UTSI supports the AEDC in maintaining "state of the art" expertise in both technical and managerial ranks. The three physics faculty at UTSI report directly to the Head for all academic matters, including faculty workload, faculty evaluations, graduate course offerings, and student mentoring. However, UTSI is fiscally independent of UT Knoxville, meaning that they have their own research contracts and faculty lines.

F. Demand for the Program

- Scientists and engineers are the brains and instigators of technological innovation that drive economic and human prosperity. Physicists, in particular, are in high demand. At UT, we not only educate and train the next generation of physicists but also provide a large number of physics service courses to engineering and life sciences majors. In addition, we provide several general

education courses to UT's undergraduate population, such as our astronomy courses. Our general education and service courses have a very high enrollment and constitute the bread and butter of our department.

- According to a 2013 *CNN Money* report, astronomers and physicists have one of the lowest unemployment rates (0.3 percent).
- The U.S. Department of Labor, Bureau of Labor Statistics, states that employment of physicists and astronomers is expected to grow 16 percent, which is faster than the average for all occupations during the 2008-18 decade (Source: Sloan Career Cornerstone Center).

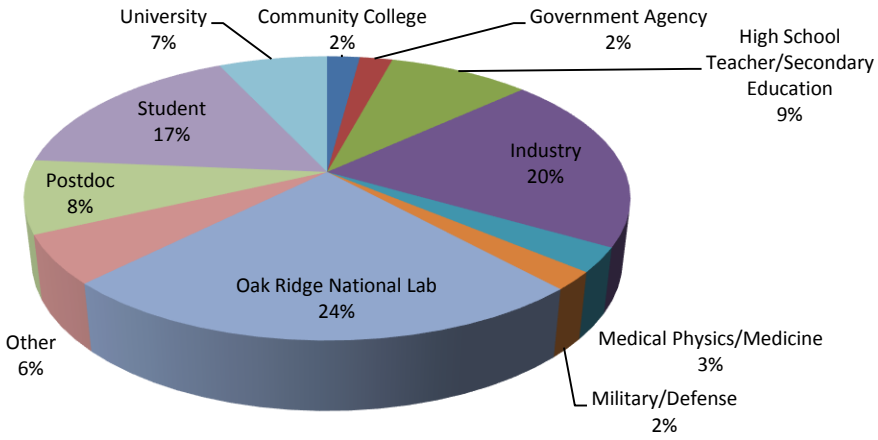

Fig. I-2 Tennessee job placements of physics graduates. The majority of physics graduates stay in Tennessee, working for government agencies and private sector companies.

- Most UT physics graduates work in industry (software & IT, space sciences, detectors, medical devices, energy, semiconductors, etc.) or academic/research environments; many others (bachelor's and master's grads) are pursuing advanced degrees. The majority stays in Tennessee (see figure below). They work for government agencies (e.g., ORNL) and private sector companies. They teach high school, community college, and university classes. They are not just physicists: they are doctors, engineers, and software developers who have physics degrees.
- Physicists are versatile, and many become entrepreneurs. One in eight responders of a recent American Institute of Physics survey of PhD physicists founded their own company. Most of those companies were physics-based, including electronics, medical devices, radiation detectors, and other physical instruments. Yet many are not related to physics at all.

G. National and International Recognition

According to the 2014 *US News and World Report* ranking, our department is ranked 40th among public universities in the US. In our 2012 strategic planning document, we compared ourselves with schools that were on the official list of UT peer and aspirational peer institutions in the Southeast. These include:

1. University of Maryland, College Park: #5
2. University of Texas at Austin: #5
3. University of Florida: #21
4. UNC-Chapel Hill: #22
5. Texas A&M: #26
6. University of Virginia: #26
7. North Carolina State University: #34
8. Virginia Polytechnic Institute: #37
9. **University of Tennessee: #40**
10. Louisiana State University: #43
11. University of Georgia: #51
12. University of Kentucky: #60
13. Auburn University: #72

Unfortunately, our ranking dropped from 2013 (#33) to 2014 (#40). On the positive side, our faculty has won major awards while at UT, including:

- The winner of the 2011 Tom W. Bonner Prize, which is the highest honor in nuclear physics in the U.S. (Nazarewicz, who left in 2014).
- Five elected Fellows of the American Association for the Advancement of Science, and 11 elected Fellows of the American Physical Society (including Professor Dai who left in 2013).
- Two Department of Energy Outstanding Junior Investigator Awards (2007 and 2009).
- Three National Science Foundation CAREER Awards in Three Years (2012, 2013, 2014).
- Society of Physics Students, UT Chapter, was named an Outstanding Chapter by the national SPS in 2013, (Honorable Mention in 2012), 2011, and 2009.
- Campus recognition: In the past 10 years, physics students and faculty have won 52 UT Chancellor's Honors. Two of the three JIAM Chairs of Excellence were physics faculty.
- The French-US Theory Institute for Physics with Exotic Nuclei (FUSTIPEN) is directed by the Physics Department through JINPA, as was the previous Japan-US Theory Institute (JUSTIPEN).

II. Programs and Initiatives

A. Fostering Diversity

A general guiding principle of the department's strategic plan is excellence in diversity. The department is committed to develop a more gender and racially diverse faculty, staff, and student composition than what is currently the case in physics departments all over the US. To improve gender diversity, the department aggressively pursued and was awarded two "Target of Opportunity Hires" in nuclear physics. Dr. Christine Nattrass joined the faculty in August 2012, and Dr. Nadia Fomin joined in August 2013. Both are outstanding young scientists, and their hiring was explicitly coincident with the department's strategic plan. Dr. Nattrass also has a track record of working actively and effectively on diversity issues. In 2012, UT hosted the Southeast Conference for Undergraduate Women in Physics. Dr. Nattrass organized this event.

Physics graduate students have a less diverse background than the UT graduate student population as a whole. Before 2014, the department did not keep statistics on the ethnic background of students who received an offer of support. In 2014, we made six offers to females; one was accepted. We made two offers to Hispanic Americans, both were accepted. No offers to other underrepresented minorities were made because we had no qualified applicants. The department is now developing a diversity recruitment plan to increase diversity in our applicant pool and will apply to become a member institution of the APS Bridge Program in January 2015. The department is committed to recruiting and providing support for qualified APS Bridge Fellows entering graduate school.

B. Interactions among Faculty and other Units

The department builds relationships with other units primarily through collaborative research activities. One particular strength of the department is the large number of collaborations and interactions across sub-fields of physics. In Fig. II-1, we have outlined many of these interactions between the three major groups: Sub Atomic Physics (SAP), Materials Physics (MP), and Emergent Areas of Physics (EAP).

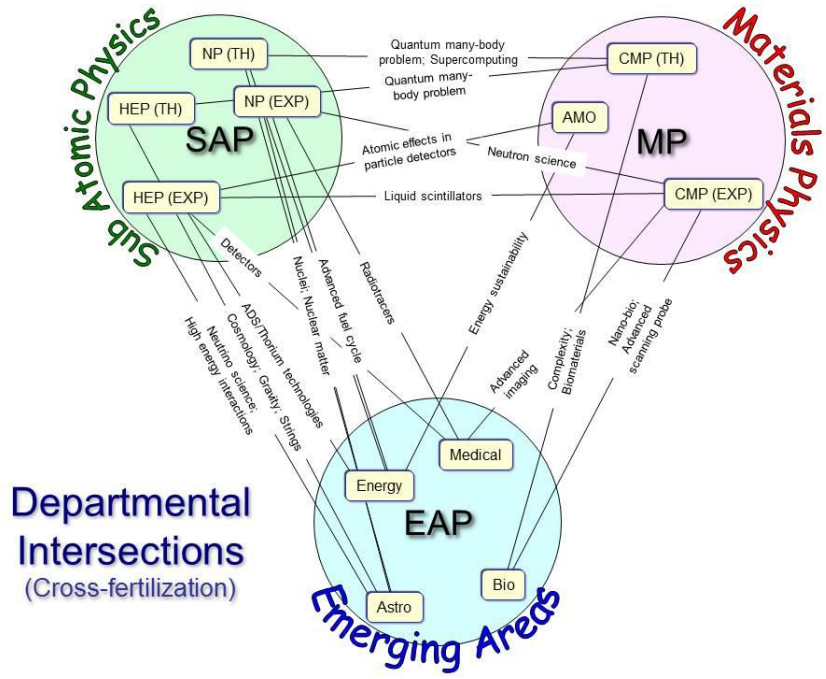

Figure II-1: Schematic diagram illustrating the internal interactions within the Department of Physics and Astronomy.

It should be mentioned that emergent here refers to the emergence of these areas within the department, and not to the emergence of these fields in physics in general.

Our department is also characterized by an exceptionally large number of external interactions with other departments in our College, other UT Colleges, and joint UT/ORNL units (see Appendix). Specific examples of these interactions can be seen through the work of graduate students, many of whom work between the Department of Physics and Astronomy and other units such as Earth and Planetary Sciences, Chemistry, CIRE, etc.

C. Community Engagement

Research Community. Research in physics is an international endeavor, as evidenced by the diverse national and cultural makeup of our faculty and student body. Faculty and students are involved in, and lead, many national and international collaborations. The most prominent interactions are those with ORNL and the UT/ORNL Joint Institutes, as described in Section I-D. The department furthermore has demonstrated leadership and generated high visibility for UT in international collaborations revolving around neutrino physics and physics at the Large Hadron Collider in Geneva, Switzerland. In addition,

the French-US and the Japan-US Theory Institutes for Physics with Exotic Nuclei (FUSTIPEN) is/was led by UT Physics faculty.

Community Outreach. Many of the outreach activities of the department are summarized on our website http://www.phys.utk.edu/outreach.html. These include our acclaimed astronomy outreach program. The department has acquired local visibility in particular from regular media coverage of astronomical events including interviews with Paul Lewis, our director of space science outreach. Many of the outreach activities (including telescope viewing sessions) take place at elementary and middle schools in Knox and surrounding counties, on the roof of the physics building, and at nearby state and national parks. Additionally, our new planetarium is expected to draw in even more visitors.

Other outreach efforts are targeted at middle and high schools along with their teachers. It includes an effort led by Lecturer Christine Cheney targeted specifically at middle school girls. These hands-on inquiry-based activities are part of the Gadget Girl Adventures in STEM (GGAS), an annual collaboration between UT and the Girl Scouts Council of the Southern Appalachians, and strive to interest girls in science, technology, engineering, and math at an early stage. Other faculty members mentor students from local high schools and provide them with research opportunities at UT.

The department also participates in the Tennessee Governor's School for the Sciences and Engineering, a summer programs for gifted and talented high school students. The four-week residential program encourages individual academic growth in a particular subject matter taught in a rigorous core curriculum. In addition to a course in Modern Physics taught recently by Professor Mannella, several faculty have participated by delivering lectures and/or showcasing their experimental facilities.

Finally, the department has a strong tradition in disseminating the importance of key research findings to local, state, and national audiences and to global audiences via internet and website postings. Physics faculty members are regularly invited to present a "Pregame Showcase Lecture" about their research. These lectures are hosted by the Dean of the College of Arts and Sciences and start a few hours before a UT home football game. The audience includes alumni from all over the nation, professionals from across the state, and the general public. The Pregame Showcase is supported by the UT Office of Alumni Affairs, WUOT-FM (NPR affiliate) radio station, and UT Athletics. The event is highly publicized through print and electronic media.

D. Ethics and Professional Behavior

The training of Graduate Teaching Assistants in the Department of Physics and Astronomy has been a priority for many years, but more recently emphasis has been placed on preparation to transition former undergraduate students, who are now graduate students, to their role as teacher. Inherent in this new role, graduate teaching assistants now have control and power which they must wisely learn to use ethically and professionally. A set of subjects is presented in an orientation workshop prior to the beginning of classes in the fall. The workshop consisted of 8 half-day sessions this past fall semester and 5 of these were devoted to professional conduct, producing quality instruction, and not cutting corners. Treatment of students, personal interactions, professional behavior, and sexual harassment topics are discussed. New pedagogical teaching methods were presented such as Active Learning, Peer Instruction, Fundamentals of Teaching, Problem Solving, and Critical Thinking. Professional responsibilities and expectations are discussed. GTAs should be on time, be prepared, and return graded lab reports promptly. They are taught that they are being paid to teach and their students should expect to be taught well and receive value for the tuition they have paid. They are taught that

sexual harassment can take different forms, and that instructors should monitor their behavior with vigilance to avoid any inappropriate behavior that may be more tempting in their more powerful and controlling role. Three sessions of the orientation workshop are devoted to hands-on training relating to the experiments that the GTAs will be teaching. This is critical for them to begin their work fully prepared to meet the challenges.

E. Transparent and Data-informed Decision Making

The Department strongly values transparency and shared governance. All faculty and selected staff members (if appropriate) serve on departmental committees. All major issues that affect the teaching, research, and outreach activities of the department are discussed within the relevant committee(s). Committee findings and/or recommendations are presented in faculty meetings and are usually followed up with a motion for a faculty vote.

The department has been proactive in data gathering to evaluate its performance. Perhaps the clearest example of data-informed decision making was the 2011/2012 benchmark study used to develop the 2012 strategic plan. Here we defined a number of quantifiable benchmarks that reflect the core activities of the department. We compared our performances in these activities to those of physics departments at selected peer institutions.

F. Management of Resources and Infrastructure

Human Resources and Infrastructure. Generally speaking, the department is doing more with less. Compared to the 1990's, the faculty has shrunk by about 10 FTE. Since 2005, we have lost one FTE in the machine shop and one FTE in the electronics shop. We also lost a full time lecturer. We added one FTE in the business office. We have lost about 5 percent of our research space since 2005. Yet the department produces more research papers and graduates more students than ever before.

The most cost effective way of operating the department is to invest in quality. The department strongly invests in faculty start-up funds so as to recruit the best and the brightest. Here we can claim success as our junior faculty members have won three prestigious NSF Career and two DOE Early Career awards in recent years. With the recent increase of our endowment, we began making highly competitive offers to recruit the best and the brightest (under)graduate students, especially women and minorities. We also recruited highly-qualified professionals to run the main and business offices, which have since become highly efficient and professional. Under the new leadership of Ricky Huffstetler, our machine shop is run better than ever before and delivers quality products better than any other shop on campus. The department is also committed to enhance the qualifications and performance of our existing staff by actively promoting and financially supporting additional training for relevant professional certifications.

Finally, we use departmental resources to improve research infrastructure and our class rooms. The department provides matches on both internal and external instrumentation proposals that enhance our research infrastructure. Preference is given to projects that impact a large number of people. In addition, we use departmental funds to improve the learning environment for our students through, *e.g.*, classroom renovation and by purchasing state-of-the-art instructional technology.

Financial Resource Management. The department aggressively manages financial resources to maximize achievement of its academic and research objectives. This entails knowing our financial position at any given time in order to make informed decisions. The business manager is a CPA with more than 25 years of experience prior to UT, including state auditing, federal auditing, and experience as the CFO of a regional non-profit agency.

The business office produces monthly financial statements within one week of month's end that encompass all departmental accounts and accurately project the financial position at fiscal year-end. These statements provide senior management with information needed to confidently commit or defer commitment of financial resources. Examples of wise fiscal management include:

- Proactive management of sponsored programs, including monthly summaries and ledgers to each PI and alerts to upcoming problems and deadlines.
- Using sponsored program funding to progress graduate teaching assistants to research assistants for the second half of their PhD program.
- Aggressively seeking multidisciplinary funding for efforts and needs that cross department lines.
- Seeking "match" participation from the college and other university offices for appropriate projects.
- Receiving approval to reserve released salaries for startup funding of future faculty hires.
- Creatively managing endowment revenue to address a $100K deficit in GTA funding.

To conclude this section, we emphasize that the department has become "leaner and meaner" since the previous program review. We believe we have reached the limit of what we can do with the limited funds available. There is no doubt that a significant increase in ranking would require the department to rejuvenate and grow into areas that are highly fundable. Furthermore, the department will need to increase its number of endowed scholarships and professorships to bring the best people on board.

III. Undergraduate Program

A. Overview

The department offers both a major and a minor in physics. Three major concentrations are available: academic, general, and astronomy. Our academic concentration is intended for students contemplating graduate work in physics. The general concentration was designed for those who wish to apply a substantial knowledge of physics to a non-traditional career path. Fewer physics courses are required, but an additional 12 hours of coordinated coursework in a field of the student's choice must be satisfied. We are very flexible about how students satisfy this latter requirement, which we approve by individual petition, as it is not possible for DARS (UT's degree audit reporting system) to enforce. Since the introduction of the VOLSTeach program, the general concentration has been the choice of most students seeking a credential in secondary education with the intent of teaching physics in high school. Astronomy is popular among students, and our astronomy concentration helps provide preparation for graduate work. Although moderately popular, we have dropped our engineering physics program for several reasons. The College of Engineering no longer supported it, as it was their only unaccredited program and the difficulty of obtaining accreditation was deemed too great for its limited enrollment. Noting its small enrollment, THEC slated the program for elimination as a cost-saving measure. In fact, engineering physics required no courses not already taught and so no money was saved by its elimination. Several years ago a program was added whereby a student could obtain an engineering degree and a MS in physics in hopes of fulfilling a need no longer met by engineering physics. We were apparently overly optimistic in this hope, as nobody has yet entered the program.

B. Curriculum

Students prepare for our sophomore-level courses by one of three routes (see Appendix for a complete course listing). Two are traditional two-semester calculus-based sequences, one of which is designated as an honors course. These courses are taught in a variety of ways, as will be discussed below. The third provides a path for students from the College of Engineering to major in physics. These students learn

mechanics in Engineering Fundamentals 151 and 152 and electricity and magnetism, waves, optics, and modern physics in our Physics 231 and Physics 232. These four courses constitute the third route by which students can satisfy our sophomore prerequisites. Engineering students have been required to take EF151 and EF152 for many decades. The mechanics content of these courses is substantially different from our introduction, focusing more on statics and equilibrium and less on conservation laws, planetary motion and rotations. Nonetheless, we feel the 4-semester series is adequate to prepare for our junior-level mechanics 311.

In the sophomore year, most students study modern physics (fall semester) and thermal physics (spring), followed in the junior and senior years by yearlong sequences in mechanics, electricity and magnetism, and quantum mechanics. Also, laboratory courses in optics, electronics, and modern physics are completed. These requirements are fairly typical of physics programs nationally.

We are in the process of adding a new course, Physics 451 - A Survey of Contemporary Physics, to the curriculum and to the requirements for the academic concentration. We consider this an important addition for several reasons. First, it is the only semester-long exposure our seniors receive in physics beyond the textbook, as it is currently practiced by the research community. Second, we are seeking Oral Communication (OC) designation so that our majors can satisfy simultaneously a major College General Education requirement. Lastly, we have included this course in two proposed Connections Packages with courses from other departments, again to help our students satisfy new College requirements, scheduled to begin in fall 2015. Our majors who already have one of the highest major credit-hour requirements in the College will benefit from this double counting.

An important component of our senior laboratory experience is the Modern Physics Laboratory. Developed and taught by our Director of Laboratories, Dr. James Parks, the included experiments are challenging and state-of-the-art. Unfortunately, the physical space they occupy is marginal. We believe this laboratory should be a departmental showcase that we can proudly show to potential majors, donors**,** and other dignitaries and visitors. As Dr. Parks prepares for retirement in a year, this is the perfect time to restructure this laboratory. Dr's. Kate Jones and Christine Cheney have accepted this challenge, and a physical space with great potential has been identified on the second floor.
While most of our courses are for majors, most of our credit hours taught come from service courses. We serve students in engineering, pre-health, architecture, and general education. Many students in other science majors take our major courses, particularly introductory physics. Primary examples include computer science, geology, and mathematics.

C. Student Recruitment

The physics department relies on a multi-pronged approach to advertise our undergraduate program to prospective students. They have the opportunity to tour our classrooms and labs on a one-on-one basis or in small groups, hosted by an associate department head. They typically meet with the director of the undergraduate program and the department head, and sometimes sit in on physics classes.

The department dedicates a section of our website to focus on the undergraduate program. The information is reviewed every academic year to make sure all degree requirements and options are up to date and in agreement with the *Undergraduate Catalog*. We include sections on “What is Physics?”, “Why Study Physics?”, “Why Study Physics at UT?”, and “Where do Physics Graduates Work?” We also include current salary information, alumni profiles, and information on scholarships and research opportunities; as well as links to University, state, and discipline-related programs that offer support

for physics majors. In tandem with the yearly web review, we produce an in-house packet for potential undergraduates. Included are recent departmental newsletters that often highlight our Society of Physics Students; information from the American Institute of Physics on physics graduates and placement (e.g., physics majors score high on both the MCAT and LSAT); and a handout providing an overview of our program with short alumni profiles, employment and salary statistics, and contact information. We also post photos of students and advertise SPS events on a departmental Facebook account, following the College's idea that potential students "like to see themselves" represented in University communications, particularly social media. Our publications coordinator is part of the College's social media task force working to make the best use of this avenue to reach prospective majors and our strategy will evolve along College and University best practices. Undergraduate scholarships are another means by which the department recruits potential majors. They will be discussed in Section III-G.

D. Student Profile

Our number of degrees awarded shows a gradual increase in recent years. However, data provided by central administration suggest an almost explosive growth in our major enrollment. This is an accounting artifact resulting from the University's new requirement that all incoming freshmen must declare a major. Prior to 2011 some students were almost invisible to us as many didn't officially declare a major until just before graduating. Despite numerous survey attempts, accurate accounting proved elusive. The new requirement is a boon to us! We maintain a ListServe allowing us to maintain close contact with all majors and students expressing a so-called physics interest. We regularly send departmental information about jobs, SPS activities, seminars, etc.

We actively recruit women and minorities as majors, largely through scholarships. Nationally, these groups are grossly underrepresented in physics departments, and ours is no exception.

E. Advising

The department believes that a clear path to improvement has been outlined by the Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP) project, which set out to answer an intriguing question: Why, in the 1990s, did some physics departments maintain a number of majors much higher than the national average for their type of institution? During that decade, the number of bachelor's degrees awarded in physics declined across the country. Yet in the midst of this decline some departments had thriving programs. Four of our faculty attended a SPIN-UP workshop at North Carolina State University several years ago. Among the central conclusions of SPIN-UP is that successful departments offer "A challenging, but supportive and encouraging undergraduate program that includes a well-developed curriculum, advising and mentoring, an undergraduate research participation program, and many opportunities for informal student-faculty interactions, enhanced by a strong sense of community among the students and faculty."

Our incoming physics undergraduates are advised initially by professional advisors in the College. This is as it should be as these advisors are much more conversant with the full range of gen-education requirements. We also assign all physics majors to a departmental faculty advisor. Our departmental advisors are dedicated, committed, and knowledgeable. But, as a group, we are not proactive. We tend to meet with students at their request, sometimes for advice about classes, careers, graduate schools, etc., but most commonly to clear a registration restriction in place until a student meets with an advisor. To bring our advising more in-line with SPIN-UP conclusions, we intend to contact, preferably

by phone, each physics major twice per semester to inquire about their physics experience. In the process, we hope to offer our help and encouragement to each student and to identify ways in which, as a department, we can be supportive.

As part of its SACS reporting requirements, the department now administers a 30-question survey each spring (see Appendix). In spring 2014, 10 out of 11 graduating seniors participated. On a scale from 1 to 5, they produced an average score of 4.1, the same as for the spring 2013 survey. This average score meets the departmental SACS goal. Two individual students each produced an average score of below 3.5 and scored questions 8 – 12 very low. Questions 8 – 11 concern professional activities, associations, or clubs, hands-on research experiences outside of the classroom, and opportunity for meaningful interaction with faculty in research or other scholarly activity. The department's goal is to help all physics majors have a research experience outside the classroom, either by working with faculty in the department or through an external program. The department's very active Society of Physics Students (SPS) often addresses issues these two students reported with their departmental experience. The survey results seem to suggest a correlation between being involved with this professional organization and being aware of research opportunities.

F. Teaching

Among the sciences, Physics Education Research (PER) has been at the forefront of developing innovative and effective teaching strategies. Among these is the classroom use of Personal Response Systems (PRS), or "clickers" to engage students during lectures. Many of our faculty has used this approach for many years, dating from the use in the late 1990s of analog clickers (flash cards).

The department was also an early adapter of Studio Physics. Developed at North Carolina State, the technique eliminates the traditional class lecture and laboratory dichotomy, replacing it with a class featuring several student activities guided by faculty or GTA input. Students work in small groups at round tables to encourage cooperation while intermittent faculty/GTA mini-lectures serve to introduce material. The laboratory of a retiring faculty member was converted for this purpose, and Dr. Stuart Elston developed the first science course at UT to employ the technique and has taught Physics 135-Physics 136 using this approach for several years. Dr. Marianne Breinig transformed our pre-health sequence, Physics 221-222, away from the traditional lecture/laboratory to incorporate inquiry-based activities. Many of our introductory courses are now taught variously as traditional lecture/laboratory, Studio Physics, online, or mixed format, depending on instructor.

New research opportunities are also a tool used to attract undergraduate students. The physics department offers financial support for students in the form of fellowships and part-time employment. The undergraduate Summer Research Fellowship program is designed to give outstanding undergraduate students the opportunity to gain experience in physics research. Each research fellow receives a $4000 fellowship and spends 10 weeks working full-time on a research project supervised by a physics faculty member. Students learn research procedures and techniques while exchanging ideas and experiences with other program participants, graduate students, and physics faculty. Dr. Marianne Breinig coordinates this program.

As an example, Mr. Eric Martin, a recipient of the Summer Research Fellowship Program in 2010 and 2011, conducted original research with the Mannella research group for two years. He received multiple awards including the department's Robert Talley Award for Outstanding Undergraduate Research in 2010 and 2011, first place at the Student Poster Presentation at the 2011 Annual Meeting

of the Tennessee Section of the American Association of Physics Teachers, and the Division of Earth and Physical Sciences Award at UT's 15th Annual Exhibition of Undergraduate Research and Creative Achievement (EUReCA). Mr. Martin wrote a successful application for the Chancellor's Honors Research Grant that supported travel expenses for data collection at the ALS synchrotron in Berkeley, and presented his work in an oral presentation at the 2011 March Meeting in Dallas. He became co-author of two manuscripts; one published in *Phys. Rev. B*, the other in *Phys. Rev. Lett*.; and he is now a graduate student in the Physics Department at the University of Colorado, Boulder.

Overall, our undergraduates have become increasingly involved with research, much more so compared to our previous review. Many of them already get involved during their freshmen year. By the time of graduation in spring 2014, 75% of graduating seniors in the 2013-2014 year had experience in undergraduate research.

G. Scholarships and Awards

Apart from the undergraduate research scholarships mentioned above, which are funded primarily through the UT/ORNL Science Alliance, the department has quite a few endowed scholarships. They are listed in the Appendix. We actively encourage our undergraduates and incoming freshman to apply for these scholarships. Applications and/or nominations are being reviewed by a Fellowship and Scholarship Awards committee, consisting of the graduate and undergraduate program directors and the associate heads, who then make a recommendation to the Head. Since we began a defined program in 2002, we have awarded scholarships to 99 undergraduates, resulting in 36 degrees, including masters and doctoral degrees granted to students recruited through undergraduate scholarships who stayed with UT physics for graduate work. Twenty undergraduates are still enrolled.

To improve our retention and yield we revamped our program in the 2011-2012 academic year, requiring incoming freshmen to meet with the director of the undergraduate program before receiving their scholarship funds. With the exception of three students, every undergraduate (21 total) who has received an undergraduate physics scholarship since the fall term of 2011 has either earned a physics degree or is still in the program.

Each spring, the department awards distinctive honors to deserving undergraduates: the Outstanding First Year Physics Student, the Douglas V. Roseberry Distinguished Upper Class Major Award, the James W. McConnell Awards, and the Robert Talley Awards for Outstanding Undergraduate Research and Outstanding Undergraduate Leadership. The faculty selects the winners based on student dedication to scholarship, leadership, and excellence.

H. Enrichment

Our local chapter of the Society of Physics Students (SPS) has a strong history of attending, and hosting, SPS zone meetings where physics colloquia and seminars are scheduled, student talks and posters are presented, and close interaction with students and faculty from other institutions is fostered. The department actively sponsors SPS, particularly for travel to student conferences.

SPS has also hosted workshops on finding undergraduate research opportunities and applying to graduate school, as well as an annual picnic. Many other outreach projects are conducted annually by SPS involving both on-campus and community contact.
Beyond SPS activities, the department sponsors a summer research fellowship program pairing

qualified students with physicists on campus and at ORNL to work on projects and present their findings; see Section III-F. The department sets aside space for an undergraduate lounge in the physics building, invites all undergraduates to the weekly colloquia series, and appoints an undergraduate liaison through whom students can voice their requests or concerns to the department head.

I. Student Success

The department graduated 77 bachelor's alumni from 2009 through summer 2014. We have placement data for 58 of those graduates, with a breakdown as shown below.

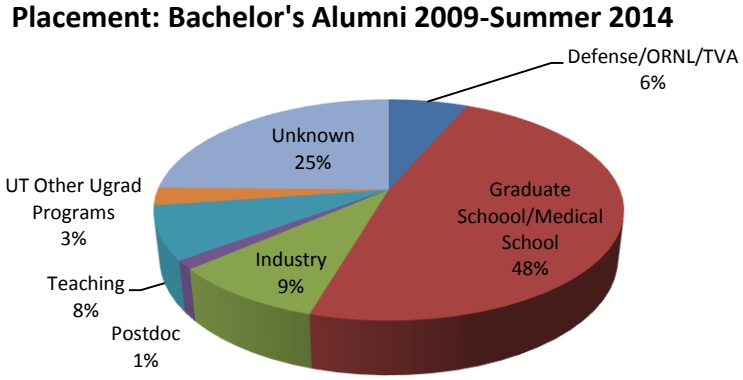

Figure III-1: Placement data for physics bachelors who graduated between 2009 and 2014.

Here, graduate programs include aerospace engineering, applied geoscience, atmospheric sciences, business analytics, chemistry, physics, materials science and engineering, math, medical physics, nuclear engineering, and science writing. Note that our graduation numbers are slightly different from those provided by Central Administration (and listed in the Appendix), as we include **calendar** years 2009-2013 and the spring/summer terms of 2014. We also count graduates in Engineering Physics.

IV. Graduate Program

A. Overview

The department offers graduate degree programs leading to a MS and a PhD degree in physics with a choice of concentrations. The master's degree program offers thesis, project, and non-thesis options. The graduate degree programs at the University Space Institute (UTSI) in Tullahoma are an integral part of the UT programs. Degree requirements for physics students at UTSI and at Knoxville are identical. Our graduate programs couple a strong academic foundation with research opportunities at some of the best research facilities in the world. While enrolled in a physics graduate program, students can earn an Interdisciplinary minor in Computational Science or a minor or MS in Statistics to "round out" their education. The UT Physics graduate program was rated #65 by US News in 2014, higher than any other listed graduate science program at UT.

The graduate program is essential for the physics department to fulfill its teaching and research mission. Most graduate students start their degree program as GTAs, taking courses and teaching undergraduate physics laboratories, before joining one of the department's research groups in their

field of interest and becoming graduate research assistants. PhD students are required to pass a Qualifying Exam before the beginning of their fourth semester to stay in the program and to form a PhD committee before the beginning of their third year.

Approximately 20 new graduate students join our department each year. Some students later switch from the MS to the PhD program, or vice-versa. At the beginning of the fall 2014 semester 107 students were enrolled in the physics graduate programs at UT and UTSI. The number of students enrolled fluctuates by approximately five percent from year to year.

B. Curriculum

All physics graduate students are expected to complete the graduate core curriculum, consisting of Physics 521/522 (Quantum Mechanics), Physics 531 (Classical Mechanics), Physics 541 (Electromagnetic Theory), and Physics 571 (Mathematical Methods in Physics). Students in the PhD program are also expected to take Physics 551 (Statistical Mechanics). Students in the MS program must complete a minimum of 30 hours of course work listed in the graduate catalog with a minimum of 18 hours of courses at the 500 level. Students in the PhD program must take a minimum of 48 hours of course work listed in the graduate catalog, which must include 15 hours of 600-level courses, with six of these hours in their area of concentration. In addition, PhD candidates must register for 24 hours of course 600 (Doctoral Research and Dissertation). A complete course listing can be found in the Appendix. We have implemented several curricular changes since the 2005 academic program review:

- The new "energy science and engineering'' concentration is offered in collaboration with the Bredesen Center for Interdisciplinary Research and Graduate Education, a joint effort between UT colleges and ORNL.
- The Graduate Research Participation Seminar is a required course for incoming graduate students. Every week one or two faculty members will speak about their research and answer student questions. Students learn about available research opportunities and are expected to contact research groups to identify potential graduate research advisors.
- Interdisciplinary classes at the 600-level: While our core curriculum is rigid, students have flexibility in fulfilling advanced course requirements. Students are encouraged by their research groups to take interdisciplinary classes offered by other departments to fulfill 600-level course requirements.
- We began offering graduate course in growing fields, as identified in the department's strategic plan. These include:
  Physics 642: *Quantum Computation and Quantum Information (2 semesters)*
  Physics 642: *Biophysics (1 semester)*
  Physics 643: *Computational Physics (1 semester)*
- UTSI faculty offer online classes for UT and UTSI students in Contemporary Optics, Laser Physics, and Nonlinear and Quantum Optics.

During the 2013/2014 academic year the graduate curriculum committee examined the graduate curriculum in detail and is planning to make recommendations to the faculty during the current academic year. Discussions have focused on reducing the number of required 600-level courses by one, introducing new 500-level courses that better prepare students for advanced work in their area of concentration, and adding computational components to core courses to make sure all students acquire computer programming skills.

C. Student Recruitment

To grow the pool of applicants to our graduate programs the department deploys various strategies. Our departmental website informs students about our degree programs, highlights research opportunities, provides a glimpse of students that have recently graduated, and directs students to the Office of Graduate Admissions to apply. Faculty members use their personal contacts with colleagues and undergraduate students at US and international universities and research facilities to inform undergraduate students about the opportunities in our program. Faculty members also recruit at regional APS meetings, which often have a large undergraduate research component. We have a very active section of the SPS, and we host and attend many SPS meetings where we encourage undergraduates to apply to our graduate programs.

A committee of faculty members evaluates the applications. Over the last two years we have significantly tightened our requirements for admission with support. We now require (not just recommend) a GRE subject test score. An initial measure of success in our PhD program is passing a qualifying exam. We find the GRE subject test score a better predictor of success in our PhD program than the GRE A or GRE Q score. Our main criteria in making admission decisions are GPA, GRE subject test score, recommendations from UT physics faculty members, and external letters of recommendation. GRE subject test scores of students that are likely to be successful in our graduate program will vary, depending on the undergraduate program from which the students are applying. The department relies on its experience from previous years to evaluate these scores. Undergraduate research experience factors into faculty recommendations and external letters of recommendation. The department makes offers to qualified applicants without regard to ethnicity and gender, but tries to increase diversity in the applicant pool.

The academic preparation of our incoming graduate students is improving. The charts below show the yearly increases in the average scores of the diagnostic exam (taken upon arrival for advising purposes only), and of the PhD qualifying exam, taken one year later, for students recruited with financial support. The average GRE physics subject test score hasn't changed much since 2011, and typically hovers around 55%. However, before 2013, fewer than 50 percent of the incoming students reported their GRE subject score whereas now, all incoming students are included in the GRE average. We will keep track of the various exam scores so as to obtain a fairly reliable predictor of student success.

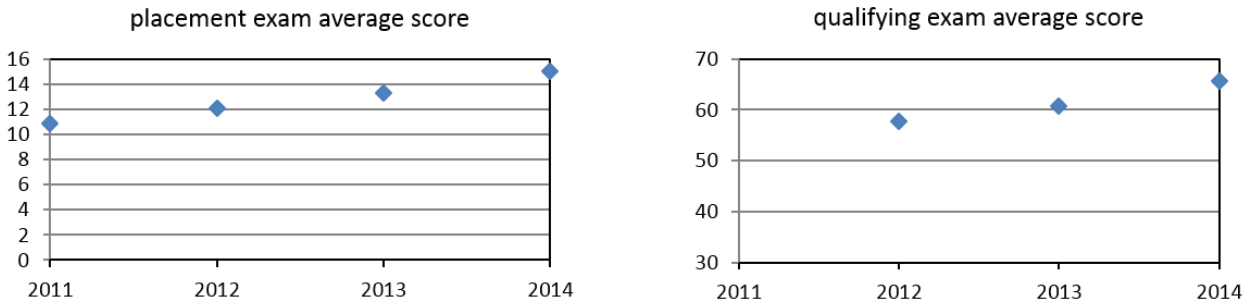

Figure IV-1: Exam scores showing gradual improvement in preparation of incoming graduate students. Students taking the placement exam in 2011 took the qualifying exam in 2012, etc.

The department aims to admit approximately 20 new graduate students with support each year. The base stipend for 2014 was $20K for nine months of teaching duty (at 0.5 FTE), plus health insurance,

paid over 12 months. The table below shows the number of initial offers we have made each year to accomplish this goal.

Offers	2010	2011	2012	2013	2014
initial offers made	51	44	38	42	38
initial offers accepted	19	21	17	15	20
yield	37%	48%	45%	36%	53%

The department also admits graduate students without support. Only students who have a reasonable chance to succeed in our program are admitted, and students who are not offered support are given the reason for this decision. Very few students join our program without support. Currently we have three unsupported first-year students.

Since 2012 the department has received Chancellor's top-off funds to increase the stipend of highly qualified applicants. The department was successful in using $3k – 5K supplements to attract good students who had offers higher than our base stipend from peer and aspirational peer institutions. Many of these students had strong recommendations from close collaborators of UT faculty members. The supplements allowed us to make competitive offers. The department tried but was not successful in attracting truly outstanding students with $10K supplements. For the competitive offers the yield was 40 percent in 2013 and 62 percent in 2014, significantly higher than for the regular offers.
The Chancellor's supplements are helping our recruiting efforts, but supplements are not enough. One of the department's highest priorities has been, and continues to be, an increase in the GTA base stipend and in the number of GTA positions in our budget.

D. Student Profile

Averaged over the past 10 years, the department admitted about 22-23 students each year. The graphs below show the number of graduate degrees awarded. Averaged over the past five years, 20 physics graduate degrees were awarded annually, which satisfies the graduation-rate goal of the strategic plan.

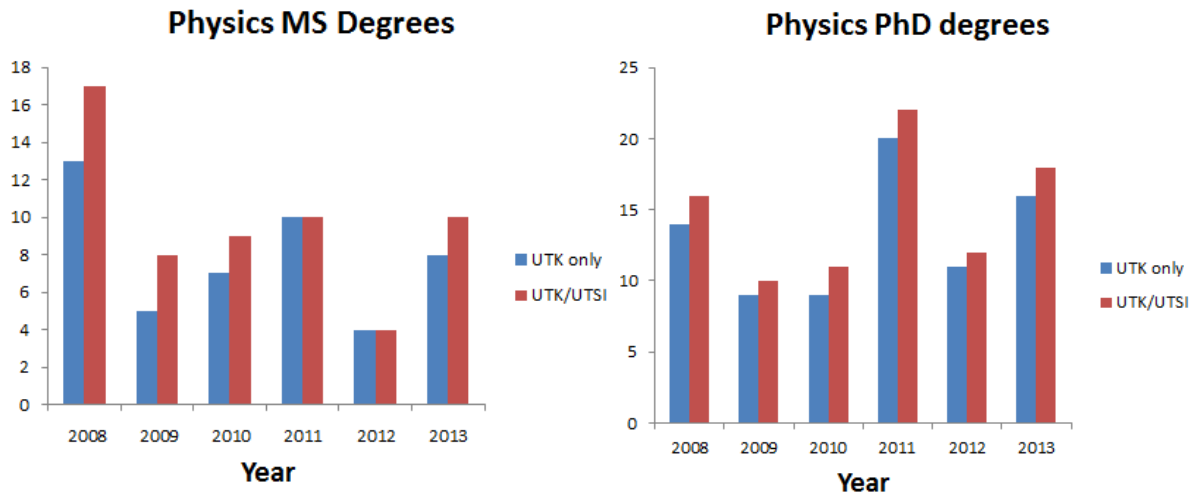

Figure IV-2: Centrally provided data of the PhD and MS degrees issued with and without inclusion of UTSI graduates.

Currently there are 107 students enrolled in the graduate program at UT and UTSI: 10 women and 97 men. Sixty-two percent of the graduate students are US citizens and thirty-eight percent are from other countries. Our student body currently includes one African American student and four Hispanic Americans. The number of offers to international students has declined over the years as the number of well-prepared US applicants has increased. Furthermore, nearly all GTA positions now involve teaching with direct student contact and, consequently, we require a minimum score on the speaking portion of the TOEFL.

E. Advising and Mentoring

Dr. Thomas Papenbrock is the designated academic advisor for all first-year graduate students. To help identify strengths and weaknesses of incoming students and to recommend appropriate courses for students with weak preparation in specific areas, all first-year graduate students are required to take a diagnostic exam. Dr. Papenbrock remains the student's advisor until he or she joins a research group and becomes an advisee of a faculty member in that area. Master's students should form a MS committee consisting of three physics faculty members at the beginning of their third semester. The chair of this committee becomes the student's advisor. PhD students are required to find a research advisor and form a doctoral committee comprising four faculty members (one from outside physics) before the end of the second year of study. This committee is responsible for advising the student and monitoring his or her progress toward the doctoral degree. In general, the committee chair is the student's primary research advisor. The department requires that a candidate's committee meet with him or her at least once per academic year. The student can request a meeting without the presence of the advisor at any time. The committee is set up to help the student, who is urged to consult its members when technical, procedural, or other problems arise, and to keep them informed of his or her progress.

F. Teaching

Most three-credit hour graduate courses are taught as traditional lectures but several of these courses require more direct student involvement through presentations and individual or group projects. Physics 643, Computational Physics gives students the opportunity for semester-long projects on Titan, the #1 open-science supercomputer in the world and the first to incorporate hardware acceleration (GPUs). Physics 507, Contemporary Optics, requires students to use state-of-the-art optical design software. Many seminar courses require students to prepare reports on current research papers. Student evaluations (SAIS) of our graduate courses are very positive.

G. Scholarships

PhD students are expected to demonstrate professional development by publishing research results in peer-reviewed outlets included in the Web of Science and by making an oral presentation of the results to an external professional audience before defending their dissertation. Publication and presentation data were collected for all 2012/2013 PhD graduates. Ninety-two percent of the graduates had published a paper in a peer-reviewed publication, and 100 percent had given an invited or contributed presentation to a professional audience. We are currently collecting data for the 2013/2014 graduates.

It is expected that all MS students give a scientific presentation. This could be a thesis defense, a seminar, a lecture to undergraduate or other graduate students, an oral presentation used for a Ph.D. comprehensive, or part of the MS non-thesis test. From fall 2009 to march 2013, 79 percent of students

receiving a MS degree gave a scientific presentation to a professional audience.

H. Enrichment

To spark the exchange of ideas and to encourage interaction among scientific colleagues, the physics department organizes a weekly colloquium with invited speakers. Graduate students are required to attend the colloquia as a means of learning about future directions in physics research and developing relationships with faculty members and other students. Graduate students attend national or international conferences to present their work and to network with colleagues. Such travel is funded mostly from research grants, but, if research funds are lacking, students may receive travel stipends from the department at the discretion of the Department Head.

I. Student Success

PhD students must pass a qualifying exam before the beginning of the fourth semester of graduate studies. A seven-member committee of physics faculty members from different areas of specialization prepares, administers and grades the exam, which is given twice each year. The entire physics faculty sets the passing score. In the 2013/2014 academic year, 18 students passed and were allowed to continue in the PhD program, while three students failed and were not allowed to continue. After passing the qualifying exam, PhD students join a research group and then must write and defend a research proposal to pass their comprehensive exam.

For students graduating since 2002, the average time to a MS degree is 2.9 years and the average time to a PhD degree is 5.75 years. Most students enter the PHD program after graduating with a BS or BA degree, but a few students (12 percent in 2014) start in the PhD program after completing a MS degree. The department is making a strong effort to enforce deadlines and to ensure progress towards the degree to decrease the average time to graduation.

Since 2002, approximately five percent of the graduate students have failed in the PhD and MS program and left without a degree. From 2009 through the summer of 2014, the department conferred 138 graduate degrees. Their placement breaks down as follows:

26% University Affiliations (Postdoctoral Positions, Fellowships, etc.)
19% National Laboratories
19% Industry
12% Graduate School
8% Other/Unknown
6% University/College Faculty
4% Medical Center/Institute Affiliations
4% Military Research
2% Teaching (High School)

Industries include electronics, energy, financial services, information/data, medical applications, space sciences, and software engineering. Note that our graduate numbers are slightly different from those provided by Central Administration (and listed in the Appendix), as we include **calendar** years 2009-2013 and the spring/summer terms of 2014.

V. Research, Scholarship, and Creative Activity

A. Overview. The department has a very broad research program in areas of condensed matter physics; atomic, molecular, and optical physics; nuclear physics; computational astrophysics; high energy physics; and biophysics. In addition we cover areas like medical imaging, micro-sensor physics, accelerator physics, and applied laser physics through our adjunct faculty. Our research programs are heavily intertwined with our teaching mission since all of these programs revolve around graduate education, while an increasing number of faculty involve undergraduates in their research activities. In the following, we briefly summary the strengths in key research areas. The Appendix includes listings of all faculty and their research areas (under 2015 AIP listing), faculty resumes, and research highlights (under Physics News Items).

Nuclear Physics and Computational Astrophysics. The nuclear physics group consists of eight experimentalists (Efremenko, Fomin, Greene, Grzywacz, Jones, Nattrass, Riedinger, Read, and Sorensen) and six theorists (Guidry, Hix, Mezzacappa, Papenbrock, Platter, and Steiner). Its broad research program consists of experiments in fundamental neutron science, experimental and theoretical low-energy nuclear physics and nuclear astrophysics, experimental nucleon substructure, and experimental relativistic heavy ion collisions. Several members of the group are joint faculty with ORNL. The group's members carry out their experiments at national and international facilities with leadership roles at the nearby Spallation Neutron Source. In fundamental neutron sciences, key science questions concern the electric dipole moment and precise lifetime of the neutron. In the physics of nuclei, research focuses on the structure and reactions of rare isotopes, and on detector development. Relativistic heavy ion collisions and the quark gluon plasma are studied within the PHENIX collaboration at RHIC and the ALICE collaboration at the Large Hadron Collider (LHC). Theorists study a range of problems in the physics of nuclei, nucleo-synthesis, and core-collapse supernovae. They benefit from supercomputers at UT and ORNL, and are members of the national SciDAC-3 NUCLEI collaboration.

Condensed Matter Physics (CMP) and Chemical Physics (CP). The combined CMP/CP group consists of four experimentalists (Compton, Mannella, Weitering, and Zhou) and five theorists (Dagotto, Eguiluz, Johnston, Moreo and Quinn) with a combined 7.1 FTE. The group strongly focuses on correlated electron phenomena in complex oxides and iron-based superconductors, surface physics, and nanoscience. Theoretical expertise in the group includes both *ab-initio* density functional approaches as well as numerical many-body methods. Experimental expertise includes bulk crystal growth, epitaxial synthesis, scanning probe microscopy, photoemission, soft x-ray spectroscopy, and physical property measurements. Several members of the group have joint appointments with ORNL and interact with other units on campus under the umbrella of JIAM. JIAM also houses user facilities for electron microscopy and nanoscale fabrication (see http://jiam.utk.edu).

High Energy Physics (HEP). The experimental high-energy physics (HEP) group consists of four experimentalists (Efremenko, Handler, Kamyshkov, and Spanier) and one theorist (Siopsis). The group is involved in the CMS experiment at the LHC, and reactor- and accelerator-based neutrino physics experiments, such as WATCHMAN, PROSPECT at ORNL, and Nova at Fermilab. The group has been involved in various particle physics experiments with an impact through hardware development and construction, data analysis, and management of sub-detectors. The physics analyses included: 1) b-quark and c-quark spectroscopy, 2) non-standard model quark investigations, 3) studies of neutrino oscillations, and 4) the Higgs boson discovery. The group also contributed in other areas, such as radiation detector development, satellite shielding, and non-proliferation monitoring techniques, in collaboration with the nuclear engineering department at UT.

Biophysics. The department considers biophysics a highly promising growth area and recently hired two young faculty members, one theorist (Joo) and one experimentalist (Mannik). Dr. Joo's research focuses on theoretical understanding of genetic networks. Dr. Mannik's research aims to provide physics based understanding how bacterial cells are organized spatially and temporally. The research combines experimental techniques from biophysics, molecular biology and micro-engineering and computer modeling. In addition to Dr. Joo and Dr. Mannik, several UT faculty conduct related research. Dr. Siopsis (theoretical HEP) has become involved in developing the theory of bacterial chromosome organization using tools such as field theoretical techniques and the renormalization group. Dr. Davis at UTSI has an interest in expanding his experimental work in single-molecule spectroscopy to applications in biotechnology and biological systems. Soft matter physics carried out by Dr. A. Sokolov (Chemistry) also has close links to biophysics. According to the 2014 strategic planning update, the department anticipates making several new hires in soft matter/biophysics within the next five years.

Physics at UTSI. The UTSI physics department currently has three full professors (Crater, Davis, and Parigger). Their research activities encompass biophysics, atomic and molecular physics, laser physics, chemical physics, quantum optics, spectroscopy, fluid physics, and theoretical physics. Graduate research opportunities in applied and computational physics are available with the Center for Laser Applications, and with research groups at the Air Force Arnold Engineering Development Center.

B. Funded Research

In FY 2014 the department had $8.4 million in actual funded research expenditures, roughly 1.6 times the academic (main E account) funding. This funding represents 60 open grants and contracts at any given time, 52 full time GRAs, 27 full time post docs, and nine full time research scientists. The department produces roughly 22 percent of the total research funding in the College of Arts and Sciences, second only to the combined Biology Division. We are third in terms of F&A generation,

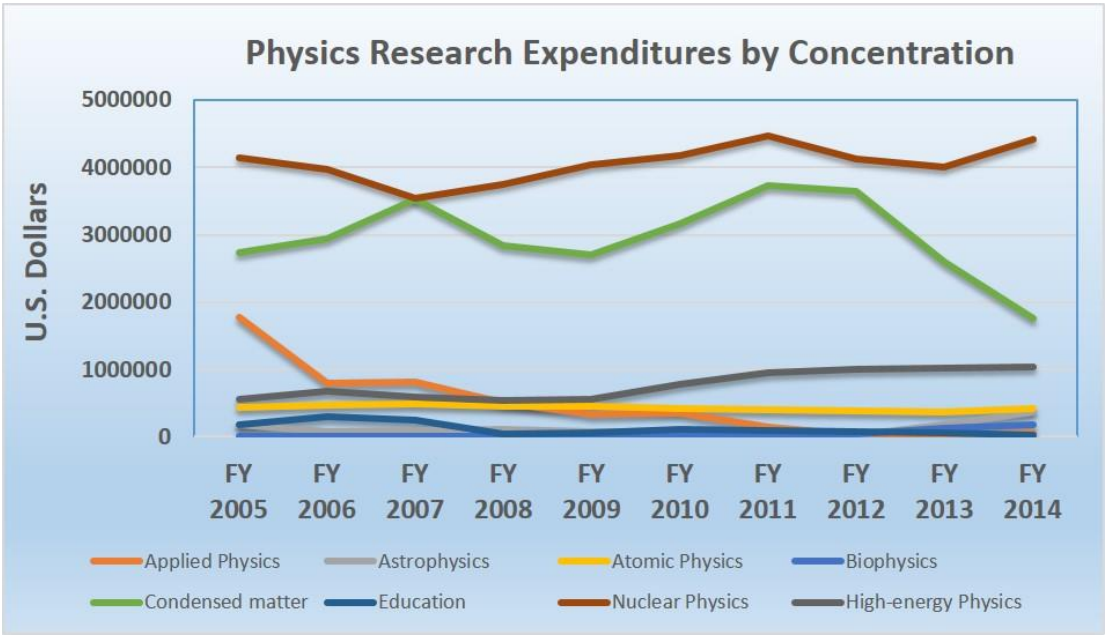

Fig. V-1. Historical development of research funding for each sub-discipline.

behind the Biology Division and Chemistry. Since 2005, our research expenditures have fluctuated between $8.2 million and $10.0 million annually. The most recent high of $9.8 million was in FY 2011.

Federal grants, mainly DOE and NSF, account for roughly 50 percent of total research funding with our ORNL alliance providing roughly 25 percent. The remaining 25 percent is a diverse mixture funding from other universities, states, and private sources. Fig. V-1 shows the funding per research area over the past 10 years. Nuclear Physics and HEP have witnessed a healthy growth, while condensed matter appears to be in serious decline. The latter can be attributed in large part to the attrition of CMP faculty. Contracts labeled “Applied Physics” are largely from ORNL adjunct faculty.

C. Multidisciplinary Research

The department actively solicits and participates in multidisciplinary research. We routinely partner with the College of Engineering, Joint Institutes, and others to seek research funding and to administer joint awards. Examples include recent proposals for NSF-MRSEC, NSF-STC, NSF-AFOSR EFRI and DOE-EFRCs. Several of our faculty are involved with the Chemical Physics program at UT (https://www.chem.utk.edu/~cp/index.php), which is co-directed by Chemistry Professor Janice Musfeldt, and Professor Robert Compton, who has a joint appointment in chemistry and physics.

We have a close and vital relationship with ORNL which includes more than $2 million in direct research contracts. The ever expanding Joint Faculty program with ORNL now has six university-based joint faculty and 16 ORNL-based joint faculty. The department is closely involved in joint efforts with the national lab that include JINPA, JINS, JICS, CIRE, and others.

Our faculty conducts research all over the world, including experiments at the Large Hadron Collider in Geneva, the Relativistic Heavy Ion Collider at Brookhaven National Lab, Jefferson Lab in Virginia, Fermilab near Chicago, the National Institute of Standards and Technology in Maryland, the Advanced Light Source at Berkeley, Elettra synchrotron in Italy, Triumf in Vancouver, the Kamioka Liquid Scintillator Antineutrino Detector in Japan, and several others. We develop relationships with other universities to jointly accomplish research. In FY 2014 these partners included Rutgers University, Rice, Louisiana State University, Columbia University, University of South Carolina, and Vanderbilt.

VI. Faculty and Staff

A. Faculty Profile

The number of tenure-line faculty has hardly changed since our midterm review in the fall of 2009. However, there has been a huge turnover due to retirements, attrition, and, fortunately, many new hires. In 2009, we had 33 faculty members for a total of 26.0 FTE and no open lines. We now have 33 faculty members for a total of 27.4 FTE and ongoing searches. These numbers do not include the three faculty members at UTSI. We included two-page NSF-style resumes of each tenure-line faculty member in the Appendix.

Since the fall of 2009, we have hired the following faculty: Jaan Mannik (experimental biophysics), Christine Nattrass and Nadia Fomin (both in experimental nuclear physics), Haidong Zhou (experimental CMP), Steven Johnston (theoretical CMP), Anthony Mezzacappa (computational astrophysics; JICS Director; 50 percent JFU), and Lucas Platter and Andrew Steiner (both in theoretical

nuclear physics). In addition, we are currently searching for a junior faculty in experimental CMP and a senior faculty member in theoretical CMP to replace John Quinn as the Willis Lincoln Chair of Excellence professor.

Professor Jim Thompson (experimental CMP), Carrol Bingham (experimental nuclear physics), and Distinguished Professor Joe Macek (theoretical AMO) have since retired. In addition, John Quinn (theoretical CMP), Robert Compton (CP/experimental CMP), and Horace Crater (UTSI) will retire in the summer of 2015. We furthermore lost several high-profile faculty to other institutions, including joint faculty professors Zhenyu Zhang (theoretical CMP), Pengcheng Dai (experimental CMP) and Witold (Witek) Nazarewicz (theoretical nuclear physics). To fully appreciate the losses in CMP, we also mention Distinguished Scientist and NAS member Professor Ward Plummer and Assistant Professor Victor Barzykin (theoretical CMP), who left shortly before 2009. On balance, nuclear physics has strengthened substantially while condensed matter has declined dramatically. High energy physics remained constant while astrophysics increased a notch with the hiring of Tony Mezzacappa (50 percent JFO). These personnel changes are quite clearly reflected in the funding distribution. The overall funding level has gone down since 2011 as grants were lost. We are optimistic about the future, however, as several young faculty are winning major NSF and DOE awards.

While the recent boost in junior faculty hiring has been great news for an aging physics department, it will be necessary to move forward with a very ambitious faculty-hiring plan. Specifically, in order to make up for dramatic faculty departures, primarily in condensed matter physics, and the announced/anticipated retirements in mostly condensed matter, AMO, and high-energy physics, it will be necessary to request two new faculty lines each year for the next five years. It is absolutely essential to at least maintain our current faculty size in order to meet our teaching obligations and to reverse the downward trend in research funding. More research funds are needed to provide RA stipends to our graduate students, and to ensure their timely graduation. To move the department into the top 25 physics departments in publicly-funded universities, the faculty will need to grow substantially.

The 2014 strategic planning update suggests six hires in CMP/AMO/biophysics and four positions in HEP/NP/Astrophysics in the next five years, with a total of six experimentalists and four theorists. This reflects the faculty's assessment of what will be the most promising growth directions, both intellectually and from a future funding perspective, noting that consolidation of existing strengths, establishing critical mass in key areas, and building bridges across (sub)-disciplines are critical ingredients for building a healthy physics department.

B. Faculty Workload and Productivity

Tenure line faculty are expected to develop and maintain a strong record of research scholarship, as evidenced by a steady output of quality research papers in peer-reviewed journals, and to acquire high international stature in their professional field(s), as evidenced from the number of Web of Science citations, invited talks, professional awards, and competitive external research grants. Our full time faculty teach one course per semester and are expected to mentor graduate students in their dissertation research and to provide them with a full research assistantship. Service responsibilities include work on departmental, College, or University committees; contributions to the profession in the form of reviewing papers and proposals; organizing workshops and conferences; and service on review panels and policy boards. To a lesser extent, it also includes community outreach. Faculty who are no longer active in research have an increased teaching and/or service load. The workload of joint faculty is prorated according to the fraction of their UT appointment. The balance between research,

teaching, and service activities of each faculty member is determined in consultation with the Department Head.

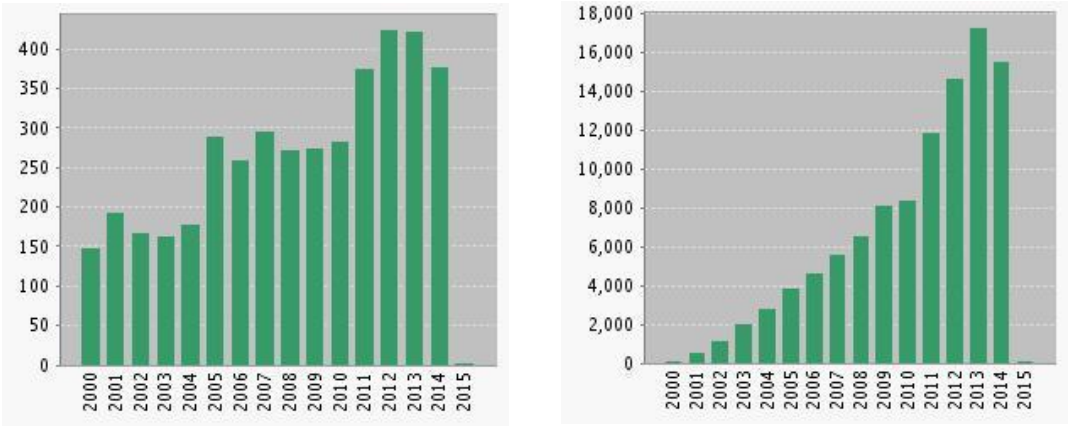

Fig. VI-1: Faculty productivity since 2000 in terms of scientific papers (left) and citations (right). Data are taken from the Web of Science. The average citation score per item is 25.03; the h-index is 119.

The graphs in Fig. VI-I reveal a significant increase in the research productivity of our faculty since our review in 2009. It should be noted, however, that these publications include publications from adjunct, research, and ORNL joint faculty. While it is difficult to verify, we probably have more non-tenure line faculty than most other departments, due to our close interaction with ORNL.

C. Staff Profile

The department has a support staff of 13 to manage its needs. They serve in six units: an administrative office, a business office, a publications coordinator, an instrument machine and fabrication shop, an electronics shop, and undergraduate laboratory operations. The administrative support office and the business office report directly to the Department Head. The others are supervised by the Associate Head for Facilities and Operations.

The administrative office provides personnel and human resources support, academic and research support, and undergraduate and graduate program support. It is staffed with three highly-qualified persons. Senior Administrative Services Assistant Showni Medlin-Crump is a Certified Administrative Professional who came to UT in 2011 with more than 18 years of experience as an executive assistant and corporate business manager. She deals with human resources, payroll, academic and research issues, and supervises the rest of the office staff. The office staff consists of Chrisanne Romeo and Maria Fawver. Ms. Romeo serves as an Administrative Services Assistant and has a bachelor's degree in Business Administration, with additional training in databases and university-specific business systems. She does general office work, but is primarily responsible for the administration of the graduate program, interacting with applicants and current students. Ms. Fawver is an Administrative Specialist with more than 21 years of experience at UT who does general office work, but is primarily responsible for the extensive travel program required for faculty and researchers working in physics' collaborative environment. The office operates efficiently and has adjusted to ever-changing deadlines, procedures, and responsibilities.

The business office is staffed with two people who provide all the department accounting, financial planning, and grants and contract management needs with the exception of travel and payroll. Business Manager Michael Roach is a CPA with 25 years of pre-UT experience in various roles, including federal auditor, state auditor, and CFO of a large regional nonprofit agency. He has been with the department for seven years. His primary responsibilities include financial management, financial statement presentation, and post-award sponsored project management. The Administrative Coordinator, Debra Johnson, has bachelor's degrees in Accounting and Human Resource Management. Her pre-UT experience includes 20 years in accounting and management for the construction industry, with responsibilities in federal contract administration and compliance. She has been with UT for five years, has taken all the university-offered training available, and has developed an extensive network of UT contacts. Her primary duties are pre-award sponsored project development and large equipment purchasing, including inventory control.

The Publications Coordinator is Catherine Longmire, who has a bachelor's degree in Communications (Journalism Major) and a master's degree in Library and Information Sciences. She is responsible for the design and maintenance of the departmental website, alumni newsletter, social media, and all other departmental publications such as student handbooks and recruiting materials. She attends meetings of campus communicators and follows university templates and policies for consistent appearances of websites and printed materials. She writes, designs, and publishes two newsletters each year that are mailed to alumni and friends of the department and posted electronically. She writes highlights publicizing faculty research, describing the work in layman's terms to be more easily understood, and works with the College Communications Office and UT Media Office to promote the department. She maintains contact with alumni, interfaces with the university development offices, and administers student scholarships made available by the department's development program. The department's publications efforts have led the College and serve as the model for better, effective communication.

The backbone of the department's experimental research program and academic laboratories is its Instrument Machine and Fabrication Shop. The shop employs four machinists led by supervisor Ricky Huffstetler. He, along with Randy McMillan, Alvin Peak, and Joshua Bell, all have been trained and received diplomas in basic machining and welding skills in area vocational and technical training schools. Mr. Huffstetler is also certified in welding in accordance with ASME Code, which is a requirement for the collaborative work requested by ORNL. They have all had training in computer numerical control (CNC) machining and can program machines using MasterCam software. CNC machining has allowed the shop staff to make more complicated and intricate pieces, and it has also greatly increased their efficiency. Presently, they have a total of 95 years of on-the-job training and are particularly adept at fabricating ultra-high vacuum chambers and hardware. The shop staff works with a variety of materials, from the simple to the complex, and no job or process seems to be too big or small or too complicated for their expertise.

The Electronics Shop is staffed with two positions. The Electronics and Instrumentation Coordinator position is currently vacant due to the recent retirement of an employee with more than 40 years' service in the department. Replacement hiring efforts are currently underway to fill the vacant position, which has been upgraded to exempt status so that a highly-qualified and experienced individual, preferably with an M.S. degree in engineering, can provide the leadership and support needed for the department's academic laboratory and experimental research programs. The Senior IT Technologist, Brad Gardner, has served physics for 25 years. He holds an Associate's Degree in Electronics Technology, has nationally-recognized CompTIA A+ Computer Certification, is a Microsoft Certified Professional, and is highly-skilled and trained in all phases of computer support and network

security. The Electronics Shop oversees the purchase, setup, and support of more than 300 department computers and 100 department printers. Installations include electronic equipment for individual staff and students, classrooms, computer labs, and research labs. The shop is also responsible for software licensing management, network support and maintenance, and fabrication and maintenance of various electronic components for research programs.

The Physics and Astronomy Undergraduate Laboratory Operations are served by two full-time staff members. Dr. James Parks is Director of Undergraduate Laboratories and is responsible for the overall operation of the undergraduate physics and astronomy labs. He presently supervises 50 graduate teaching assistants, and is responsible for their training and scheduling of assignments. He determines and schedules the experiments for each semester. He has written and published a manual for all the introductory physics experiments, and purchases and maintains all the apparatus with the help of the two shops above. In addition he teaches the advanced modern physics lab and provides oversight and support for the teaching of the electronics and optics advanced labs. Paul Lewis manages the astronomy laboratory operations, particularly the observational astronomy labs conducted on the roof of the Nielsen Physics Building. He provides training on the use of telescopes and the use of the planetarium for astronomy teaching assistants. In addition, Mr. Lewis devotes a significant amount of time to astronomy outreach, holding workshops for area teachers, giving presentations to numerous schools and civic groups, and conducting public observation sessions to involve the public in astronomical events such as eclipses of the sun. He has a strong network with local media and consequently the department is often featured on local telecasts. He keeps up with developments by participating in aerospace education and planetarium workshops.

Dr. Parks was appointed as an Associate Head in the department with the responsibility of managing academic and research facilities and supervising the electronics shop, the machine shop, the publications coordinator, and the astronomy lab management and outreach person. He is designated as an approver, with final authority at the department level to approve travel requests and reimbursements, equipment and service purchases, contracts, payroll, and position changes that occur and are reported on-line in the university's IRIS accounting and management system. Since most entries to the system are made by other staff members, by default he is left to make the final approval for almost all entries. He manages most space issues, from moving faculty and staff offices to the renovation of labs and classrooms, and is the primary interface with the university department of Facilities Services.

D. Faculty and Staff Diversity

The number of female faculty in the department increased from three (nine percent) in 2009 to five (15 percent) in 2015. While 15 percent is close to national average, we aspire to do much better and also would like to add other minorities to our faculty. To this end, we conduct broad faculty searches, so as to maximize the applicant pool, and actively pursue target of opportunity initiatives (see also Section II-A). Our staff includes seven men and six women, including one African American hired in 2009.

VII. Campus Priorities and Resources

A. Departmental Expenditures

Centrally provided state funds are administered through our primary E account. Budget categories include faculty and staff salaries, Common Instructional Pool salaries for lecturers and GTAs, Science Alliance funding, undergraduate student salaries, and other state and university miscellaneous funding.

The table below summarizes our FY2011 – 2014 expenditures from the E account, our research accounts, and the endowments. The FY 2014 E-account expenditures of $5,120,770 include about $320K in F&A return.

The University of Tennessee
Department of Physics and Astronomy
Expenditures FY 2011 - FY 2014
(Fiscal Year runs July - June)

	FY 2011	FY 2012	FY 2013	FY 2014
Academic (Main E accounts, Non Research)				
Salaries				
Faculty	2,382,842	2,424,601	2,697,746	2,809,371
Joint Faculty - ORNL based	201,000	117,459	125,399	133,912
Graduate student (non research)	700,865	726,953	762,462	866,362
Undergraduate student employees	84,565	61,862	71,453	72,643
Summer school Salaries	42,000	46,787	49,275	41,625
Total Academic Salaries	**3,411,272**	**3,377,662**	**3,706,335**	**3,923,913**
Staff Salaries	**636,050**	**672,534**	**701,943**	**733,983**
Total Salary Expenditures (Non Research)	**4,047,322**	**4,050,196**	**4,408,278**	**4,657,896**
Operating Expenditures	**446,161**	**509,359**	**509,302**	**462,874**
Total Academic Expenditures	**4,493,483**	**4,559,555**	**4,917,580**	**5,120,770**
Research Expenditures	**9,749,715**	**9,180,076**	**8,305,456**	**8,367,828**
Endowment Expenditures	**72,846**	**137,701**	**67,372**	**89,750**
Physics and Astronomy Total Expenditures	**14,316,044**	**13,877,332**	**13,290,408**	**13,578,348**

The department has financially broken even over the past four years because we were allowed to use released salaries to balance our structural deficit in GTA funds. This deficit continues to increase due to growing enrollment in our introductory service courses that require additional GTA positions.

Research expenditures have declined significantly over the four year period, primarily because we have lost some stellar faculty. It is likely that we will see an additional decline next year due to the departure of Professor Nazarewicz. It will take many years for our young faculty to reach the funding levels of those who left. It is imperative to turn the tide to ensure that our GTAs continue to progress to fully funded GRA positions in a timely manner. Furthermore, the reduction in F&A return makes it increasingly difficult to fund start-up packages, which in turn hampers faculty recruitment.

B. Development Efforts

The market value of our endowment accounts has grown from $1.9 million at the start of FY 2011 to $4.8 million currently (see Appendix for an overview of our endowment accounts and gift reports). These endowment investments produce over $190K annually that can be disbursed to students and other eligible uses. The growth is attributed to following activities:

- Twice-yearly publication of a departmental newsletter, which includes acknowledgment of all donors and a recently added “gifts in action” feature highlighting how various endowments and

funds support our students.

- Individual thank-you notes for every gift, personalized for donors based on use of funds and the donor's giving history (as a rule, the department does not send form letters).
- Distinguished Alumni Award (established in 2004) to recognize exemplary graduates and promote development.
- Honors Day ceremonies each spring include presentation of student awards, both graduate and undergraduate, sponsored by gift/endowment funds. Families are sent information about the winners, and the complete write-up is included in the spring newsletter.
- Strong involvement of the College's Development Staff with the department.

One challenge within this area is to find a strategy to optimize the financial condition of the department while adhering strictly to the terms of endowment provisions.

The department has had a Board of Advisors for many years but it is no longer active. We are currently in the process of reconstituting the board.

In reviewing the gift reports, please note that gifts, pledges, and pledge payments are all together, so these numbers are higher than actual monies received, as a pledge and the subsequent pledge payment are actually one gift.

C. Additional Revenue

Physics and Astronomy is very aggressive in seeking out new revenue to fund departmental needs. Section V discussed the sponsored projects research programs and the vital role research plays in our educational philosophy. In FY 2010, the department applied to receive lab fees. This one request has led to more than $250,000 in funding over the past five years with the annual revenue currently expected to reach $70,000. While this seems a tremendous amount, the fee is only $25. These revenues allow our labs to continually be refurbished and upgraded, providing our students with the most current educational resources.

The department also aggressively competes for and receives funding from University Technology Fee awards. Over the last four years, the department has received more than $180,000 in awards. These revenues allow us to equip classrooms with the latest technology and have been instrumental in our studio classrooms. For example, we have presently equipped a large number of faculty with tablets that allow them to display and share more educational tools with their students.

D. Space and Facilities

The department has offices, classrooms, laboratories, and support facilities in three separate buildings. Nielsen Physics Building was constructed and occupied in 1962 and currently houses the academic classrooms, instructional laboratories, faculty and staff offices, support services and operations, and the administrative offices. Classroom space is limited to five, consisting of: (1) a large room seating 220 students in an auditorium setting, (2) two medium-sized classrooms; one seating 40 and the other 60 students, and (3) two small classrooms, one holding approximately 28 students and the other holding 20 students comfortably. The smaller of the two works well for recitation sections, which are limited to 20 students. The other works well for upper-level graduate courses and seminars where enrollments are limited. The medium-sized classrooms are adequate for most of the upper-level undergraduate courses and the lower-level graduate courses. The auditorium is often filled to capacity with our

introductory offerings. All classrooms are outfitted with audio and video aids such as video projectors and document cameras. For the most part, classroom space in Nielsen Physics is adequate for physics offerings; however, classroom space in the University as a whole is lacking so that courses from other departments are assigned to physics classrooms. This limits time for advanced preparations for lecture demonstrations, etc. Most classrooms have been renovated and upgraded to keep pace with new instructional technology advances in hardware and pedagogy.

Faculty and lecturer office space in Nielsen Physics is very inadequate. There are 21 faculty/lecturer offices in Nielsen Physics Building, with an average floor space of 145 ft^2. However, removing five oversized offices from the equation, the average office size is only 116 ft^2, well below the standard target of 150 ft^2. Administrative and support staff are located in nine offices with an average size of 173 ft^2. A couple of offices have shared occupancy so interruptions can impede the flow of work.

All academic physics and astronomy labs are taught in Nielsen, and there is a particular concern that the present space will not be sufficient to accommodate the growing enrollment in the very near future. The average enrollment increase in introductory physics courses with labs has been about 75 students per year since the fall 2006 semester, from 730 students to 1330. With lab sections consisting of 20 students, this represents a need to have four additional sections each year. The increases were first alleviated by introducing courses taught by the Studio Physics method and incorporating the labs within the class sessions. The introductory offerings (Physics 221-222) for life science students, which is the largest group, were then offered on the off-semester sequence to spread the load over both semesters. Our Studio Physics classroom/laboratory accommodates 45 students per section, and this helped solve the problem, at least temporarily. However, the fall 2014 enrollment almost exceeded the available times that our labs could be reasonably used, both in our two laboratory rooms where labs are taught 'traditionally' and the Studio Physics classroom/laboratory. Several days each week, all three rooms have labs scheduled from 8:00 in the morning till 8:30, or past till 9:30 at night. This fall there were only 3-5 openings unscheduled that could be used for additional sections if some way could be found to use them without interfering with transitions from one course to another.

Room 108 on the bottom floor of Nielsen is a high-bay, large lab that was recently converted to a planetarium and an astronomy laboratory. The planetarium is designed to hold 34 persons, and because of fire code restrictions, the astronomy lab portion was reduced to 14 students. Unfortunately, this has not been a problem because enrollment in our general education astronomy courses has dropped dramatically since 2006: from 490 students to 150 in the fall 2014 semester.

Another major concern is the inadequate room we have for our graduate teaching assistants to do their work. GTAs are primarily located in two rooms on the sixth floor of the building: rooms 603 and 609. These rooms are very confining, with no windows and low sloping ceilings. The furniture is basically surplus equipment inherited from the closed super collider project. When recruiting potential graduate students who visit, we carefully avoid showing these rooms. Plans are underway to renovate additional space on the sixth floor when the astrophysics research group moves out in the spring 2015 semester. Space is needed for our graduate students to congregate, socialize, and study together. Often they are now seen using our tutorial center for this purpose, but this is far less than ideal.

There are problems with the aging Nielsen building, and heating and cooling are probably foremost among them. Steam and water pipes are continually failing and control of temperatures is at best haphazard. Each floor has its own heating and air handling system, but temperatures vary greatly between floors, without much correlation with outside temperatures. Rooms can be bitterly cold or stiflingly hot, and this condition is exacerbated by the condition of most all of the windows in the building. The mechanical mechanisms for opening or closing the windows have failed. The window panes themselves are etched with years of water dripping from the masonry above, producing an alkali

solution to cloud them up. The windows look like they need washing, and they probably do, but the worst look is due to etching of the glass. The sixth floor has suffered from leaks in the roof, particularly the flat portions. Many times papers, books, desks, computers etc., have been damaged by these leaks. As a bright spot, the off-brand, outdated elevator of Nielsen Physics was recently replaced.

The second building that physics and astronomy occupies is South College. It is the oldest building on campus, but as a historic landmark, it was renovated in the late 1980s and early 1990s. It primarily houses the faculty and graduate research assistants that do theoretical research. Although the building is old and there are occasional problems with the heating and air and the windows with old wooden sashes, it is still fairly decent space. Faculty offices are spacious, averaging approximately 220 ft^2. Graduate research areas need some attention, but this is achievable.

The third building the department occupies is the Science and Engineering Research Facility (SERF). Four faculty offices are located there and they are quite spacious, with an average size of 270 ft^2. The department has a little more than 12, 000 ft^2 of experimental lab space for condensed matter, nuclear physics, high energy physics, and biophysics. The condensed matter group will move much of its instrumentation in the near future to the nearly completed JIAM on UT's Cherokee Campus.

E. Computing Support

Computing support for students is very good. Technology Fee awards (see Additional Revenue) have allowed the department to make sure all students have access to computers which are upgraded regularly. The Office of Information Technology has obtained site licenses for most required software and upgraded the wireless network at UT to an excellent level of coverage and performance.

Research is facilitated by various centralized computing facilities. The HPC Cluster Newton, managed by UT's Office of Information Technology and Office of Research, consists of more than 400 computer nodes with more than 4200 processor cores. Newton provides faculty and students with significant computing resources. Free cycles are provided when excess resources are available. Priority access is provided to users who contributed to the cluster.

The National Institute for Computational Sciences (NICS) at UT and the Joint Institute for Computational Sciences provide faculty with significant supercomputing resources (Darter, Nautilus, and Beacon) in the form of competitive, peer-reviewed proposals or as Director's Discretionary awards. Darter is a 240 TFlop Cray XC30 distributed memory system, Nautilus is an 8 TFlops SGI Altix system with 4TBytes of shared memory, and Beacon is an energy-efficient supercomputer with accelerators. Concerns exist concerning the failed attempts for the replacement of UT's KRAKEN supercomputer.

F. Library Support

Nearly all our usage of the library is through electronic access to journals and databases. By and large, the current subscription coverage is adequate.

VIII. Summary and Perspective

This self-study document provides a snapshot of the current state of the Department of Physics and

Astronomy. Overall, our own assessment is that the state of the department is healthy and strong. Compared to the last major review in 2005, we have improved the quality of our undergraduate and graduate programs. The number of undergraduates increased significantly and the graduation rate almost doubled. Research productivity measured in terms of publications went up. Among the major strengths of the department identified in the document are:

- A distinguished faculty with a broad research profile and an excellent publication record.
- Well-funded research programs in key areas.
- Strong collaborative grass root level ties with ORNL.
- A strategic plan that prioritizes growth of highly fundable campus-based research activities.
- A graduate program that is attracting better-prepared graduate students.
- Outreach programs that produce high visibility in the community.

In spite of the dramatic losses of key faculty we have been very fortunate to recruit eight new faculty within the past five years. Nonetheless, major challenges are still ahead of us. They include:

- Loss of faculty due to retirement or attrition. About one third of the faculty is about 65 years or older and their replacement over the next five-to-10 years will be a very costly endeavor because of high start-up needs, especially for experimental condensed matter.
- Reversing the downward trend in our research funding, especially in condensed matter. The loss of F&A limits our ability to provide matching funds on startup packages and/or fund other initiatives.
- Increase the quality and diversity of our graduate student pool. We can claim some successes, but we have not been able to recruit the very best with extraordinary financial aid offers.
- Our structural deficit of GTA funding of about $100K annually could derail departmental operations at any time. Even more GTAs will be needed in the coming years to meet the rising instructional demand. A structural problem requires a structural solution.
- We have been unsuccessful in finding common ground with ORNL concerning the hiring of new Governors Chairs (GC). It is our opinion that the process needs to change but it is unclear if the UT upper level administration would support an overhaul of current practices.
- Increase the opportunities and visibility of faculty and students within the UT/ORNL Joint Institutes, building enough critical mass through interdisciplinary collaborations within the institutes to land big center proposals and expand research capabilities (including core facilities) on campus. It will make UT a much more attractive place for both students and faculty.
- Increase the rather dismal levels of salary compensation for departmental staff.
- Aging building and lack of adequate space to house our faculty and GTAs and meet the increasing enrollment in our service courses.
- Endowment increased substantially during the past five years. Nonetheless, much greater effort is needed to bring our development effort to the next stage. The Board of Visitors needs to be reconstituted.

These challenges and concerns cannot, however, remove the feeling of great optimism about the future, especially now that we have so many young faculty on board. Their impact on the department's research and teaching mission is expected to become increasingly profound in the coming years. We have a great faculty and staff who have been able to improve the department substantially over the past decade. We have more and better students than before. We are well positioned to move to the next step in national and international recognition and to even better serve the citizens of the State of Tennessee.