# Strategic Plan

## Department of Physics and Astronomy
## University of Tennessee, Knoxville

Fall 2011-Winter 2012

Developed by the departmental Planning Committee:

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# Introduction

The Department of Physics and Astronomy has over the last two decades had a tradition of creating strategic plans to guide the future development of the department. The most recent plan was developed during the academic year 2005/2006 and contained a set of recommendations for areas of future hires. Several of the recommendations have been implemented and some opportunity appointments – not envisioned in the plan – have been made. Since the last planning exercise, the research environment of our department has markedly changed, as well as the educational landscape. In particular, the rapid development of the UT/ORNL interactions with the Joint Institutes, additional State of Tennessee funds for hiring a new set of Governor's Chairs, establishment of new Centers such as CIRE (UT/ORNL Center for Interdisciplinary Research and Graduate Education), and other funding opportunities, have all made the current plan somewhat out of touch with the new landscape surrounding our department.

To enhance the quality and competitiveness of our department, assess new opportunities, and demonstrate our long-term vision, the Planning Committee decided in April of 2010 to start the process of developing a new strategic plan. The full faculty (tenured and tenure-track professors, Joint Faculty professors, and Research and Adjunct faculty) was asked to submit input for the new plan and in particular to answer four pertinent questions related to the development of the priorities in the new strategic plan. This request for information and the received responses are included as an attachment to this document. Based on this feedback, the Planning Committee decided collectively on the major principles and fields of future hiring opportunities. The plan has been developed based on principles consistent with the university's TOP 25 and VOL Vision strategic plans.

Our vision for the future is contained in this Strategic Plan. The Plan contains the basic principles and goals, and implementation guidelines. At a faculty meeting on Nov. 30, 2011, the plan was discussed by the faculty of the Department of Physics and Astronomy. It was unanimously approved by a ballot in February 2012.

It is the responsibility of the Department Head to lead the faculty in the implementation of this Strategic Plan. In this process, the Departmental Planning Committee will serve in an advisory role.

# Internal and external interactions

In order to develop this strategic plan, it was important for the Planning Committee to fully understand all the department's internal and external interactions. As shown in Fig. 1, our department is characterized by an exceptionally large amount of external interaction with other departments in our college, other UT colleges, and joint UT/ORNL units. We can be proud of this collaborative attitude among our faculty, and over the next decade it will be important to continue these strong external interactions, to strengthen them, and to develop new ones.

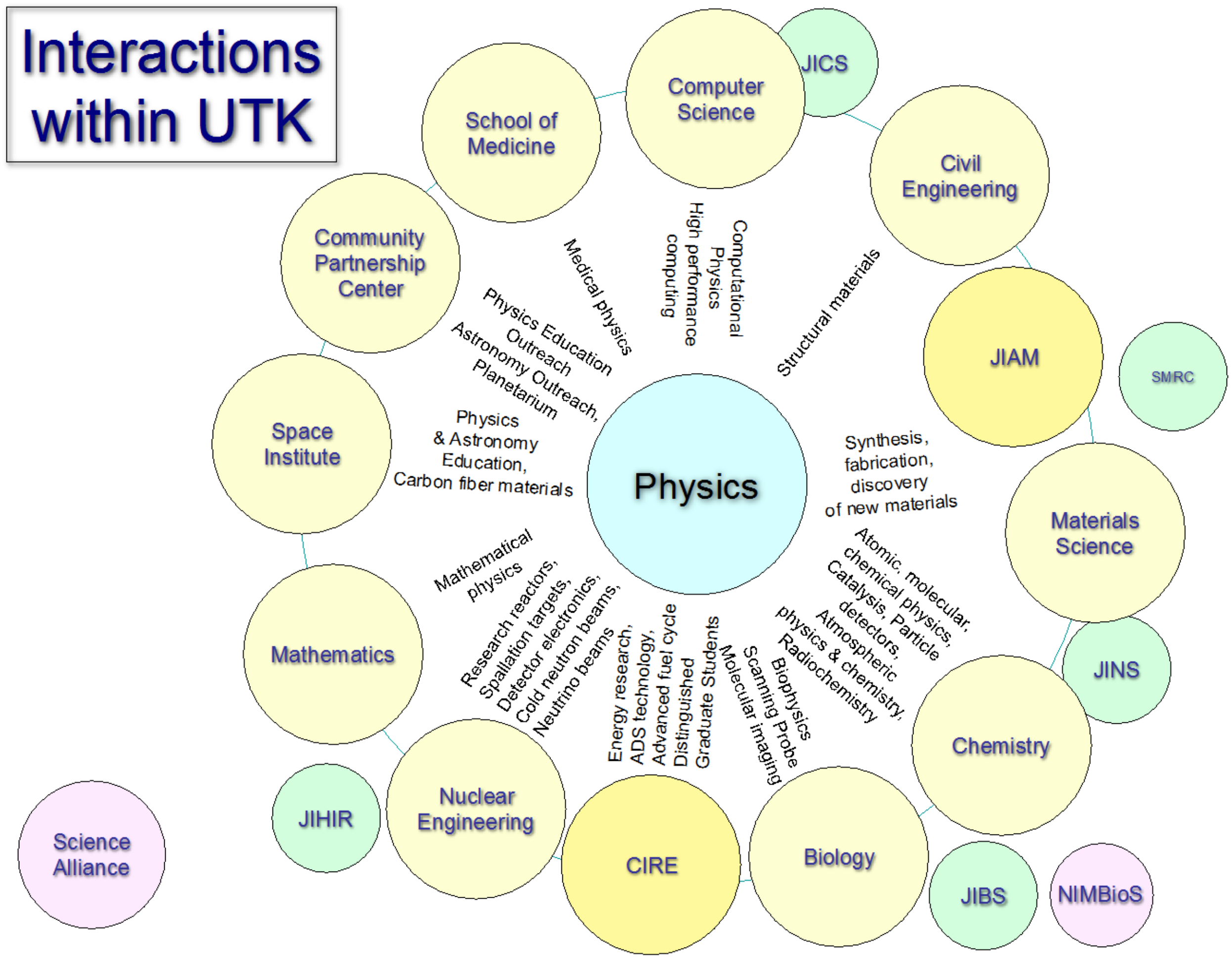



Figure 1: Schematic diagram illustrating the Department of Physics and Astronomy's interactions with other UTK units.

Our research interactions are taking place through a large number of different organizations and units at UTK, ORNL, and at national and international level. The Research Infrastructure Matrix below enumerates most of the places and demonstrates the broad scope of our faculty's research interactions.

## Research-Infrastructure Matrix

| | UT Physics | UT Other | Joint Inst | ORNL | Outside |
|---|---|---|---|---|---|
| **SAP**<br>High Energy Physics (HEP)<br>Nuclear Physics (NP) | BaBar computer Farm; Screen room facility; Clean room facility; PMT test facility; Hi-res Compton spectrometer laboratory; UV monochromator laboratory for scintillator studies; GRID computing technology (HEP), Nuclear Theory computer cluster; Digital signal processing laboratory (NP), Newton computer cluster | Chemistry, Mathematics, Nuclear Engineering, Electric and Computer Engineering | JINS,JICS (NP). Leadership of JIHIR. | Physics Division, SNS (NP, HEP), HRIBF, CCMD, CCS, HFIR, (NP). Thrust leaders in Physics Division, HRIBF, SNS. | KamLAND, Double Chooz, Fermilab, SLAC, NANO in India, Majorana@DUSEL (HEP), RHIC@BNL, ATLAS@ANL, NSCL@MSU, ISOLDE@CERN, GSI, GANIL, LANSCE@LANL, NIST, INT, ECT*, SciDAC, SSAA (NP), LHC@CERN, numerous international collaborations worldwide (HEP, NP). Leadership of TALENT (educational) JUSTIPEN (US-Japan) and FUSTIPEN (US-France) (NP) |
| **MP**<br>Condensed Matter Physics (CMP)<br>Atomic Molecular Optical Physics (AMO) | Oxide Molecular Beam Epitaxy (MBE) facility*; Semiconductor MBE facility; X-ray photoelectron spectroscopy (XPS); Two variable-temperature scanning tunneling microscopes; Low-temperature STM with Q-plus atomic force microscope*; Low-energy electron-energy-loss spectroscopy; Secondary-ion Mass Spectrometry*; Angle-resolved photoemission; Spin-resolved XPS*; Various other ultrahigh vacuum analytical tools such as LEED, RHEED, TPD; Femtosecond laser and UV photon sources; Optical characterization; Complex oxide growth facility*; Magnetic- and transport-characterization laboratory*; Two floating zone furnaces; Many box furnaces; CMP Theory computer cluster.<br>*) Shared JIAM facilities | Chemistry, Materials Science, Engineering, JIAM (CMP), Chemical Engineering, STAIR/ Biochemistry (AMO) | JIAM, JINS, JICS.<br>Leaders in the JIAM focus area of Functional Materials. | Materials Science and Technology Division, SNS, HFIR, CNMS. Chemistry and Physics Divisions; Multicharged Ion Research Facility (AMO) | APS@ANL, ALS@LBNL, NSLS@BNL, Elettra (Trieste), ISIS, ILL, FRMII, numerous collaborations worldwide, SRNL |
| **EAP**<br>Astrophysics (AP)<br>Biophysics (BP)<br>Medical Physics (MP)<br>Environmental Physics (EP) | Introductory astrophysics software laboratory (AP), Laboratory for atmospheric and remote sensing (EP), Computer cluster | BCMB, Microbiology, Chemistry, Nuclear Engineering, NIMBioS | JIHIR, JICS (AP), JIAM | Physics Division, HRIBF, CCS (AP) | FOM, Inst Plasma Phys |

Another strength of the department is the large number of collaborations and interactions across the boundaries of the sub-fields of physics. In Fig. 2 below 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). It should be mentioned that emergent here more refers to the emergence of these areas within the department, and not to the emergence of these fields in physics in general.

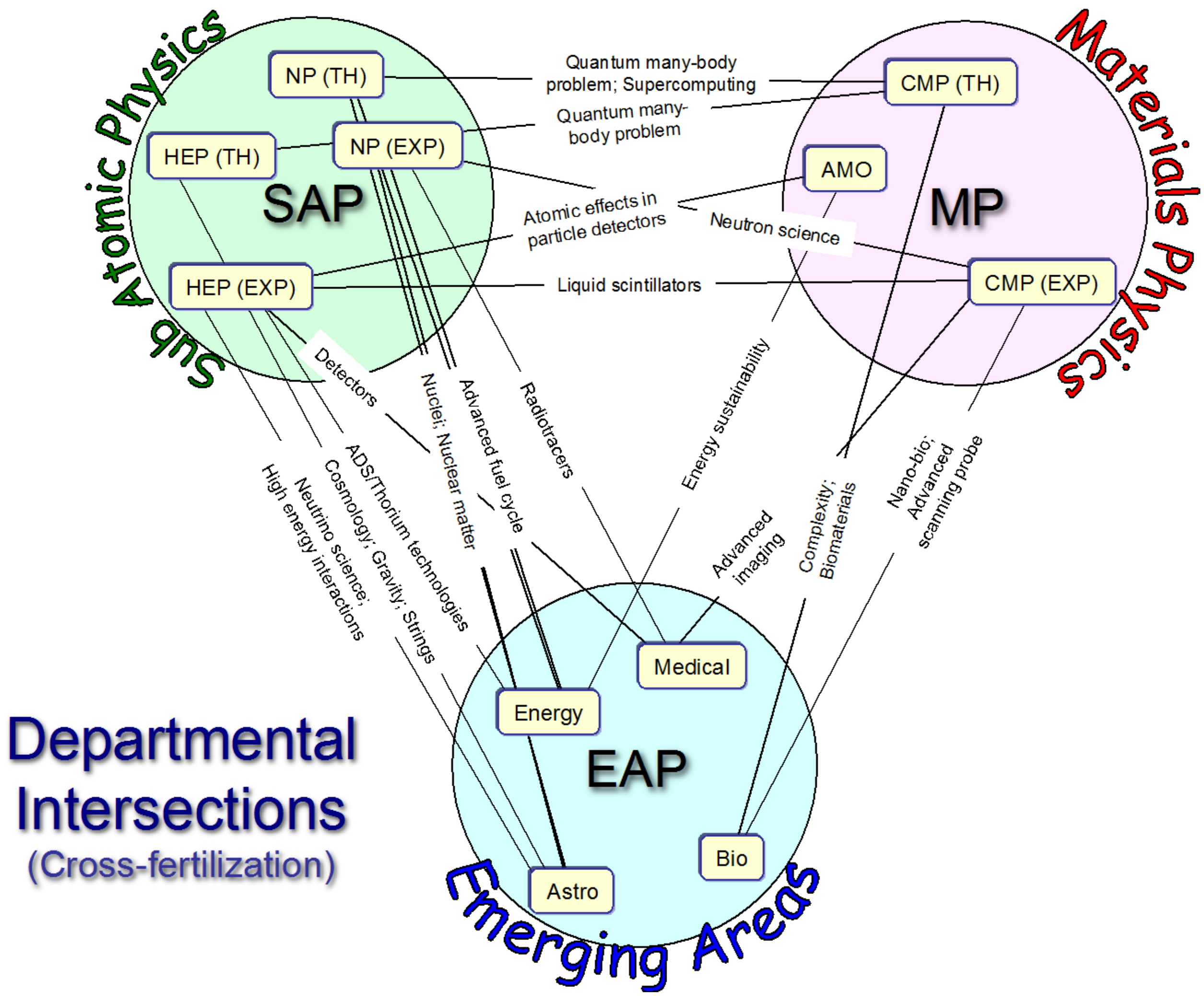



Figure 2: Schematic diagram illustrating the internal interactions within the Department of Physics and Astronomy.

# Mission

The mission of the Department of Physics and Astronomy is the foundation upon which all our strategic and tactical plans are build as well as most of our day-to-day actions. 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, astronomy, and engineering physics 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.*

# General guiding principles

Based on both the general principles expressed in the mission statement and on the particular circumstances we envision for the department over the next decade, a set of guiding principles have been developed as part of this strategic plan. Those principles, listed in an un-prioritized order, are:

**Excellence in education –** We are strongly committed to providing all our students and post-docs the best possible education through engaging classroom instruction and exciting research participation. Teaching and education are of fundamental importance to our mission and our goal is to become one of the major centers for Physics Education in the Southeast USA. We strive to achieve and maintain excellent course evaluations..

**Excellence in research –** We will only invest in people and equipment if these investments will be part of either strengthening or developing research at a world-leading level. We expect that current and new faculty (tenure-line, joint, research, and adjunct) will participate in research recognized at the highest levels.

**Excellence in diversity –** We are 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 USA.

**Excellence in new faculty -** In hiring new faculty at all levels emphasis will be placed on attracting the best possible person from an academic and research point of view independent of the specifics of the job advertisement as long as this hire is consistent with our aim towards a high level of diversity and breadth in our research. Our goal is to recruit (and mentor) leaders (or future leaders) in research and grant holders, who will execute our mission, embrace our vision, and collaborate to realize our strategic priorities. In order to rejuvenate our department, emphasis should be placed on junior appointments, whenever possible.

**Flexibility in the research fields of new hires –** Whereas this strategic plan will outline a set of areas within physics that will have our highest priority, we will aim toward maximal flexibility in attracting the best possible people to our department. The principle of replacing a retiring faculty member with a new hire in the same field cannot be upheld. At the annual Call for Faculty Search Proposals we will follow the guidelines in this plan for the submitted search proposals. However, the department will also be open to special "targets of opportunity" hires if the faculty judges this to be in the best interest of the department.

**Building a strong on-campus presence –** We are strongly committed to continue to provide intellectual leadership and build up a strong research infrastructure at the UTK campus. Our many-body theoretical effort and the new JIAM (Joint Institute for Advanced Materials) building are great examples of this on-campus research strength, but we should not stop there. In all areas of our research we will aim to have a strong intellectual and infrastructural presence on the UTK campus.

**Increase the already strong collaboration with ORNL –** The collaboration between our department and ORNL goes back more than 60 years and has been a major reason for our current excellence. We will strive to continue to make this collaboration stronger and to continue to be a leader at UTK in developing new and innovative ways for UT and ORNL to work together, with a focus on building a strong on-campus research program.

**Improve departmental cohesiveness –** The people within our department have offices and research space distributed over three, and soon four, buildings on campus as well as at ORNL. We will continue to increase the internal cohesion of the department through common research, educational, and social activities. In particular, it is imperative that we will keep the on-campus activities within a brief walking distance of each other.

**Excellence in service –** We will continue to provide professional service to the university community, the State, federal government, professional organizations, industry, and the public in areas related to physics and astronomy.

**Excellence in outreach –** We will continue to provide outreach to our various constituencies. Being an integral part of the surrounding community is very important. In particular, we will work towards strengthening of our local and global outreach efforts in physics and astronomy, in addition to increased interactions with the local high schools. Our astronomy outreach efforts will greatly benefit from the new planetarium in Nielsen.

**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 Knoxville toward peers on nationally tracked measures. To this end, we pay attention to activities that will be recognized by a consistently improved 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.

**Strengthen national and international recognition –** We will continue to work aggressively to provide major national and international recognitions of faculty and students. We will strive to create additional Governor's chairs or – by increasing departmental endowment - endowed chairs. We will continue and enhance our efforts to extend the reputation and recognition of our campus by communicating departmental accomplishments to key stakeholders. An important communications vehicle is "Cross Sections," our departmental newsletter.

**Enhance teaching effectiveness –** Each faculty member of the Department should continue or initiate activities that will enhance his/her teaching effectiveness in order to: (i) achieve or maintain course evaluations by students; (ii) graduate PhD students in a timely manner; (iii) take advantage of opportunities for faculty development (e.g., sabbaticals, summer fellowships, courses to improve teaching, etc.).

**Enhance research, and service effectiveness** - Each faculty member of the Department should continue or initiate activities that will enhance his/her research and service activities in order to: (i) achieve international recognition of prominence in his/her chosen field (as demonstrated by invited papers, conference chair positions, journal editorial positions, national and international committee memberships, consulting opportunities, etc.); (ii) publish papers in refereed journals; (iii) bring external funding; (iv) increase post-doc support; (v) fund graduate students.

# General strategic principles

Based on both the guiding principles and on the particular circumstances we envision for the Department over the next decade, a set of strategic principles have been developed as part of this strategic plan. The strategic principles for our research and educational mission are discussed below in an un-prioritized order.

## *Strategic principles for our research mission*

**Develop JIAM into a world-center for Materials Research –** The new Joint Institute for Advanced Materials and the associated building provides a unique opportunity our department and UT. We will place strong emphasis of capitalizing in every way possible on this opportunity to build JIAM into a world-leading facility.

**Develop JIHIR into a world-center for Radioactive Isotopes Science –** The Joint Institute for Heavy Ion Research is the oldest of the UT/ORNL joint institutes. Together with JIAM, it is “partly owned” by our department. New initiatives in radioactive isotopes science and applications, both in experiment and theory, uniquely position JIHIR to become the intellectual world center for this research.

**Provide strong presence in JINS, JICS, and JIBS –** The additional three joint institutes between ORNL and UT, where we have substantial interests, are the Joint Institutes for Neutron Science (JINS), Computational Science (JICS), and Biological Sciences (JIBS). We are committed to maintain strong presence within all of these institutes.

**Building a strong UT leadership in our collaborations with ORNL –** The collaboration with ORNL has to be based on a mutually beneficial relationship. In particular, we are strongly committed to making sure the members of our department are providing strong leadership in all their interactions with ORNL and that UT’s interests are well served by the UT/ORNL collaboration.

**Provide intellectual leadership in theoretical research –** In our interactions with ORNL we have found that theorists, in particular, are attracted to the academic world and that UT therefore has a particular attraction to theorists. We will therefore emphasize our role as an intellectual leader in our various theoretical collaborations with ORNL.

**Provide leadership in attracting the best possible new Governor’s Chairs –** The Department of Physics has over the last 25 years had a superior track record in defining the areas where new Distinguished Scientists are placed and attracting top-notch Distinguished Scientists, and we will place a very high priority on continuing this leadership. In particular, we will welcome as many Governor’s Chairs in our department as possible given the strong abundance of physicists at ORNL as well as a strong infusion of young people in positions associated with the hiring of new GCs.

**Provide leadership** for **CNMS –**Our department will continue to play an instrumental role in ORNL's Center for Nanophase Materials Sciences. Areas of mutual interest to the CNMS and the department include nano-biophysics, transport, and imaging functionality.

**Fully utilize all aspects of the SNS –** The Spallation Neutron Source at ORNL will be the world's best source of neutrons for many years. We are strongly committed to providing leadership within several areas associated with the SNS, such as neutron diffraction on solid and soft materials, fundamental neutron studies, and neutrino-based research. We are also committed to finding new and innovative utilizations of the SNS for the future, like a potential Muon Beam Facility and other novel ways of using the SNS.

**Expand programs related to energy research and education** - The new interdisciplinary PhD in Energy Science and Engineering presents opportunities for department faculty and students. The ESE doctorate is offered through the UT/ORNL Center for Interdisciplinary Research and Graduate Education (CIRE), and so far two Physics faculty are members of the CIRE faculty. National recruiting of CIRE graduate students and CIRE-funded fellowships can help the department recruit more top students to our graduate programs. It is important for Physics faculty to look for opportunities to apply their research to areas of energy defined to be part of the CIRE research portfolio and to provide leadership in shaping future directions for CIRE.

**Provide leadership in international collaborations –** We support the primary goals of the Quality Enhancement Program (QEP) of the University by focusing on increased and improved internationalization and intercultural relations. International collaboration is critical for strengthening knowledge and competence development. Through collaborations we can produce better science, contribute to better international practice, and also benefit from increased access to knowledge and technology. For example, our department, through JIHIR, will continue to provide leadership for the two international institutes for physics with exotic nuclei, JUSTIPEN (with Japan) and FUSTIPEN (with France).

## *Strategic principles for our educational mission*

**Increase the annual graduation rate for the undergraduate program to at least 20 –** It is of vital importance to the perceived relevance of the Department of Physics and Astronomy, both within UT and among the political leadership of the State of Tennessee, that we have a strong and vital undergraduate program that can make a substantial contribution to the education of researchers and teachers, who in turn will benefit the State of Tennessee. It is therefore our aim to more than double our output of undergraduate physics majors to at least 20 annually over the next five years.

**Increase the annual graduation rate for the graduate program to at least 20 –** The quality and size of our graduate program are among the most important factors judging the quality of our department among our peers. If we wish to substantially increase national rankings it is therefore mandatory for us to increase both the general quality of our graduate students as well as the total throughput of the graduate program to at least 20 PhDs and MSs annually. All faculty members will be expected to supervise graduate students and to obtain external funding to finance the students as Graduate Research Assistants.

**Continue leadership in developing innovative educational techniques –** Our faculty has over the last 15 years been among the leaders in developing new educational techniques by developing web-based education right after the invention of the Web, using clickers more than a decade ago, adopting peer-educational techniques, and integrating lectures and labs in our Studio Physics class room (Nielsen 206). We will continue this tradition of educational innovation through development of new courses aimed at educating physics teachers and by incorporating the planetarium into our astronomy curriculum and our educational efforts for K-12 school and the general public.

**Improve the quality of our General Education program in Astronomy and Physics –** The General Education classes as well as our service courses for other departments and colleges within UTK provide the overwhelming majority of our student credit hour production. In order for the department to fulfill its teaching mission, it is of vital importance that we constantly improve the quality and relevance of these courses and that we continue to attract many non-physics majors to these classes. In particular, we must continue to improve the educational quality of the General Education classes in Astronomy.

**Take full advantage of the new funding opportunities within the STEM fields** - Due to the needs of our state and the nation there are strong political indications that substantial amounts of funds will be allocated over the next 5-10 years for education of students in STEM areas (Science, Technology, Engineering, and Mathematics). We must take full advantage of these opportunities to attract the best and brightest of Tennessee's students to UT Physics.

# Comparing with our peers: benchmarking

**Introduction.** An essential aspect of strategic planning is a thorough analysis of the Department's current strengths and weaknesses in the areas of teaching and research. To this end, we have defined a number of quantifiable benchmarks that reflect the core activities of the Department. Our performances in these activities were compared to those of other physics departments at selected peer institutions. The methodology adopted by us and the outcome of the benchmarking exercise is presented below.

**Peer Institutions.** The peer institutions were chosen from the list published by UTK's Office of Institutional Research and Assessment (see http://oira.tennessee.edu/links.html):

- Auburn University (122)
- Louisiana State University (77)
- North Carolina State University (52)
- Texas A & M University (40)
- University of Florida (36)
- University of Georgia (77)
- University of Kentucky (85)
- University of Maryland, College Park (14)
- University of North Carolina, Chapel Hill (36)
- University of Texas, Austin (14)
- University of Virginia (40)
- Virginia Polytechnic Institute (63)

Florida State University (48) and Vanderbilt University (57) were added to the list. FSU enjoys close proximity and interactions with a national laboratory (National High Magnetic Field Laboratory), as does our department. Vanderbilt was included as the other large university in Tennessee. The numbers in parentheses are the 2010 *US News and World Report* rankings of graduate physics programs in the US, out of 169 schools. The UTK-Physics program ranks 57th on this list. In cases like Florida, Maryland Virginia and Texas, which have separate Departments of Astronomy, we compare ourselves only to the Physics Departments.

**Source Materials.** The following sources were used for the comparative benchmark analysis: (1) the American Institute of Physics (http://www.aip.org/statistics and http://gradschoolshopper.com), and (2) the Institute for Scientific Information (ISI) Web of Knowledge http://apps.webofknowledge.com. The analysis was conducted for the period 2001-2010.

**Table 1: Benchmarking results for AY2010**

| Benchmarking parameters | UTK | Peer Average |
|---|---|---|
| US News Graduate School Rank | 57 | 54 |
| Percentile rank out of 169 schools | 33 | 32 |
| Number of regular faculty | 32 | 42 |
| Fall 2010 # of junior physics majors | 17 | 39 |
| Fall 2010 # of senior physics majors | 30 | 49 |
| AY 2009-2010 Bachelor's degrees | 12 | 25 |
| Fall 2010 number of graduate students | 120 | 119 |
| AY 2009-2010 Master's degrees | 4 | 3 |
| AY 2009-2010 Ph.D. degrees | 10 | 12 |
| First term course enrollment | 2043 | 2882 |
| Enrollment per faculty | 63.8 | 81 |
| Federal research expenditures | $6,527K | $7,687K |
| State/local research expenditures | $1,703K | $5,525K |
| Total research expenditures | $8,730K | $9,141K |
| Number of ISI publications | 229 | 133 |
| Number of ISI citations | 1757 | 677 |
| Hirsch index 2000-2010 | 88 | 59 |
| Number of APS fellows | 7 | 10 |
| Number of AAAS fellows | 5 | 2 |
| **Ph.D. degrees/faculty** | 0.31 | 0.28 |
| **Total research expenditures/faculty** | $273K | $219K |
| **ISI publications/faculty** | 7.16 | 3.1 |
| **ISI citations/faculty** | 54.9 | 13.9 |

**Benchmark Parameters.** Table 1 shows the chosen benchmark parameters for AY 2010. Here, we compare the UTK Physics Department with the peer average. Normalized or "calculated benchmark" parameters are highlighted in yellow. Figures 3-6 reveal the trends for the calculated parameters over the past 10 years. Figure 7 shows the first term course enrollment per faculty.

A few clarifications are in order. "Regular" faculty is defined as a tenure-line faculty and thus excludes research and adjunct faculty. UTK/ORNL Joint faculty are included, however. This number is not equivalent to the number of full-time equivalent (FTE) faculty because quite a few faculty members have shared appointments. Also, it is not possible to verify the FTE figures from other departments. The University of Tennessee Space Institute (UTSI) is fiscally independent and is not included in the benchmarks of the Strategic Plan

Nearly all publications can be found in the ISI database service and those are the ones counted here. Books or book chapters are not included. The ISI citations in year *n* correspond to the number of citations of papers published in year *n*, as determined on the review date of November 9, 2011. The Hirsch index is a cumulative parameter for all papers published in the period 2001-2010. The Departmental Hirsch index of 88 means that 88 papers, published under departmental bylines during the period 2000-2010, have accumulated 88 or more citations. This number will have to be recalculated each year, as most of these papers will acquire additional citations in the years to come.

The Hirsch index and the ISI publications per faculty are somewhat inflated because some (but not all) adjunct faculty publish under our departmental bylines, while they are not included in the faculty count. One should assume that that is also the case at other institutions and it would be nearly impossible to filter these publications from the ISI numbers of UTK and those of other institutions. The numbers of adjunct faculty are simply not available.

Finally, the number of APS and AAAS fellows are a measure for the (inter)national recognition of our faculty. The numbers were obtained by comparing the names of faculty listed under the various departments with data provided by the APS and AAAS.

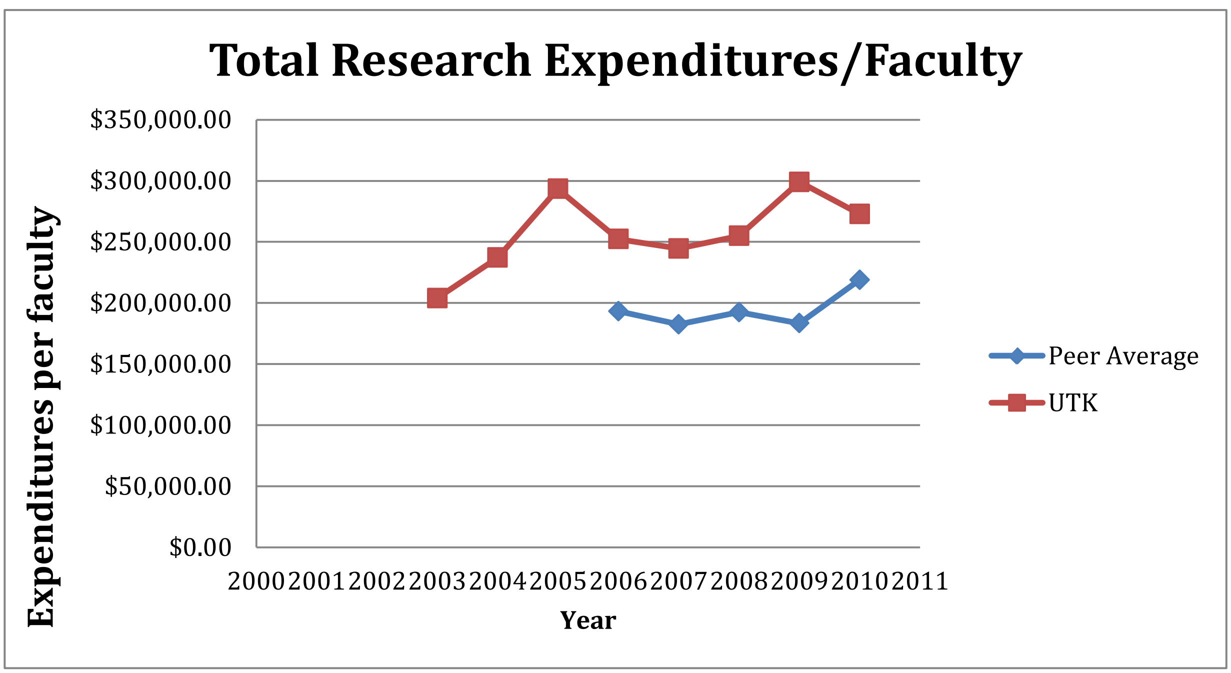



Figure 3: Total research expenditures per faculty

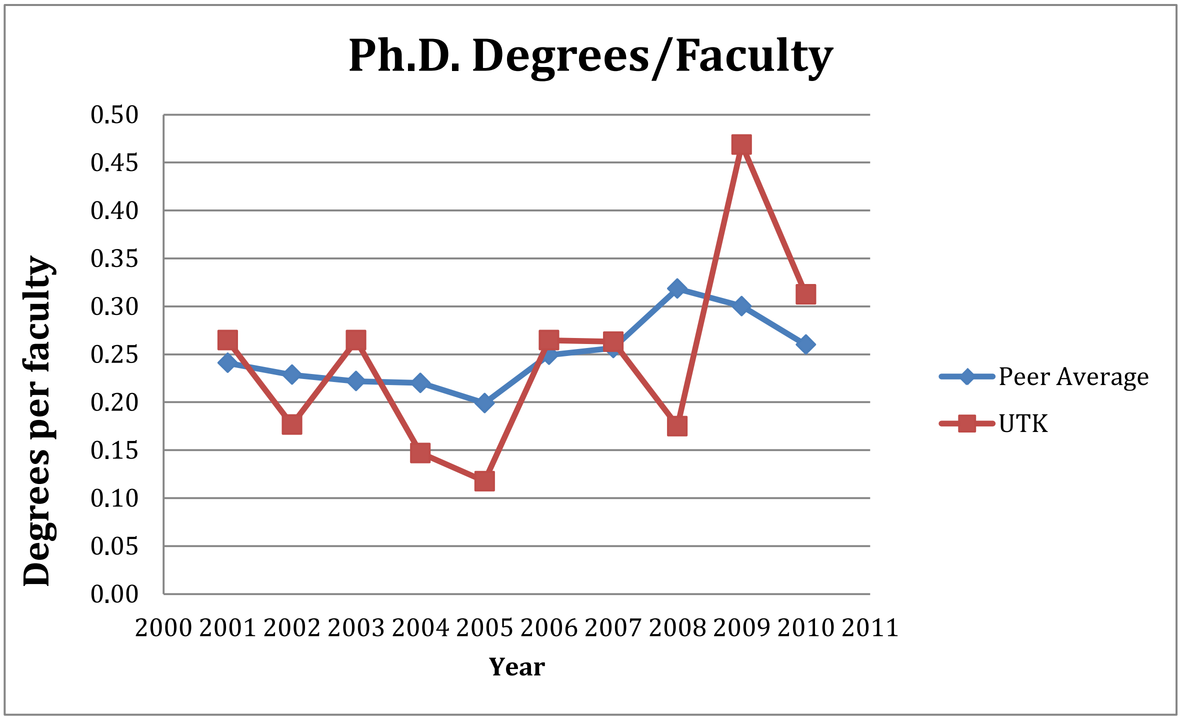



Figure 4: Number of Ph.D. Degrees granted per faculty

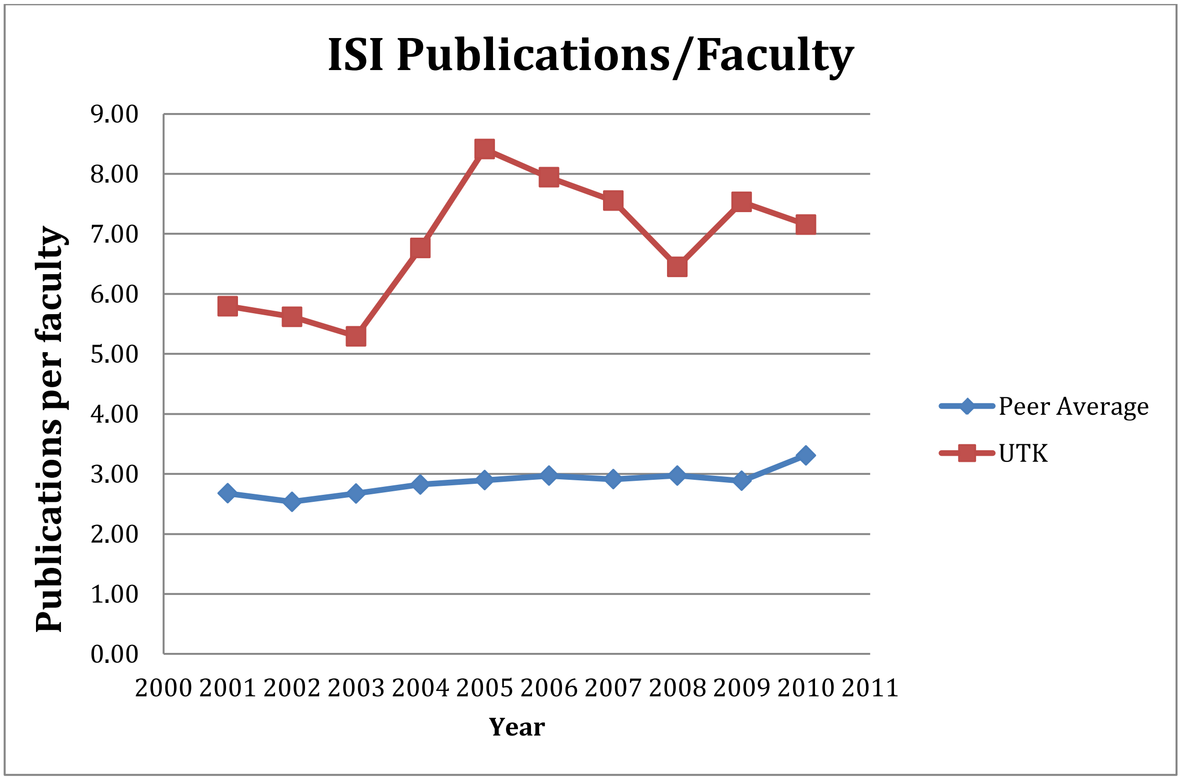



Figure 5: Number of ISI Publications per faculty

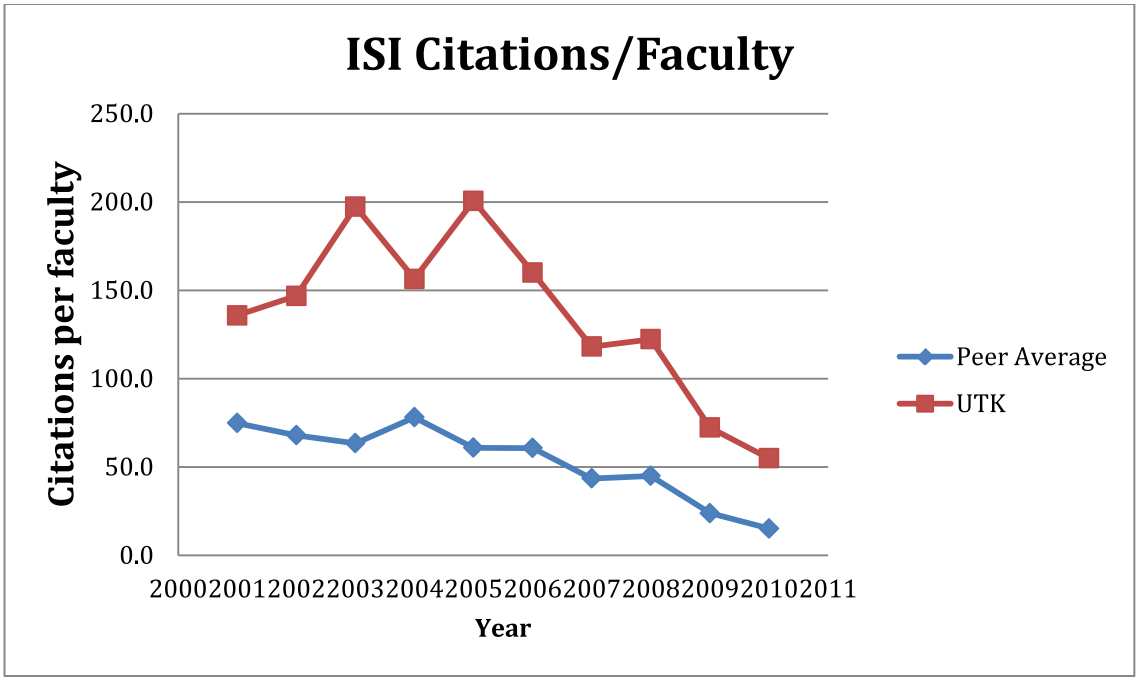



Figure 6: Number of ISI citations per faculty for papers published in year n. The review date was November 9, 2011.

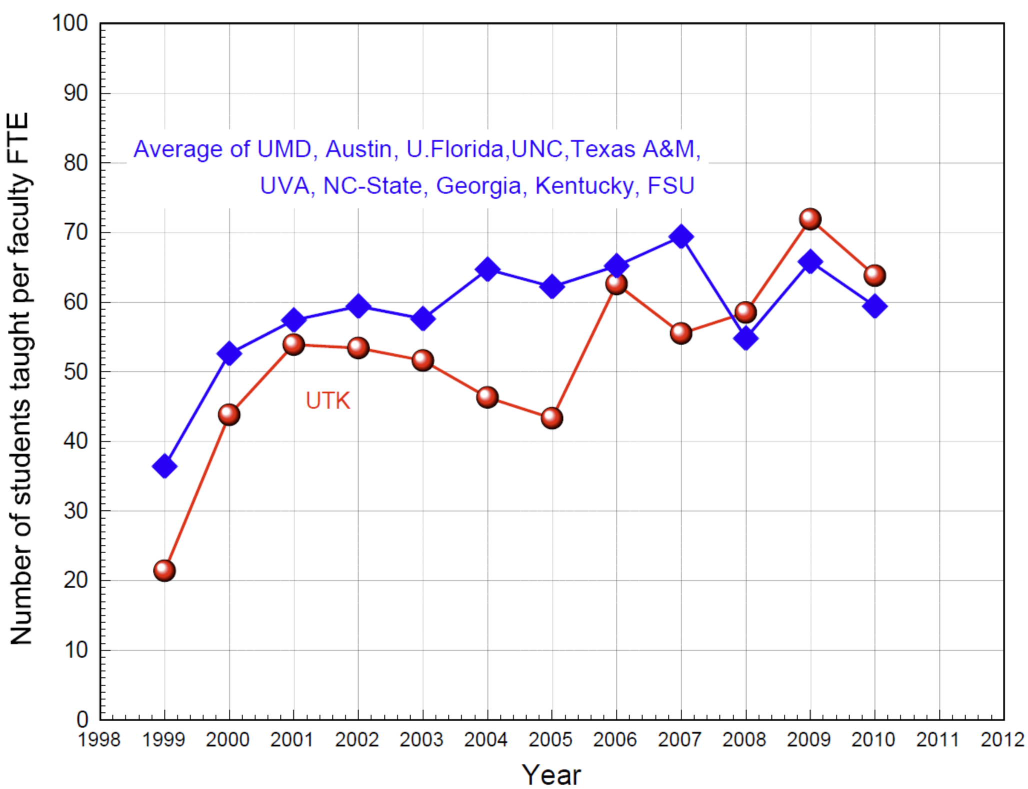



Figure 7: First-term introductory course enrollment in physics

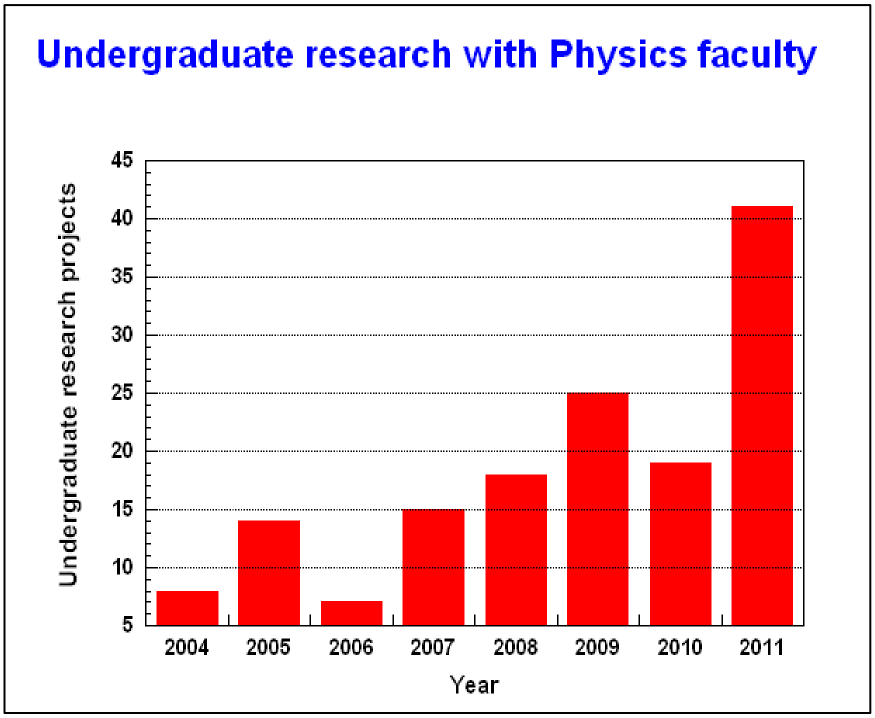


Figure 8: Documented undergraduate research projects

**Conclusion**. It appears that our department is already doing well in terms of research expenditures and research output. Also, the citation numbers per faculty are well above peer average. The number of PhD degrees is on par with the peer institutions. Our goal should be to further improve these numbers, which will be a challenge in light of the fact that we have lost some key faculty in the past few years. The low number of bachelor degrees remains a concern. During the past ten years, this number has fluctuated between 4 and 11 degrees per year and only last year, we have reached the number of 12. Small graduation numbers in undergraduate physics is an issue of national concern but our numbers are significantly below peer average. Finally, it is worth mentioning that the first term course enrollment per faculty (Fig. 7) is on par with that of our peers. This is a measure of our undergraduate classroom teaching effort, which is covered in large part by service courses. A positive development is the significant increase in the number of undergraduate students that are involved in research with a faculty member in our department (Fig. 8). These numbers are underestimated because many efforts went unreported. No such numbers are available from the other departments. It is recommended that from now on, those projects will be officially registered for credit.

# Hiring priorities

Overall the size of the faculty in the Department of Physics and Astronomy has undergone a contraction since the development of the last strategic plan in 2006 due to the budgetary cuts in FY 2008 and 2009. Especially our condensed matter program has been hit with retirements and departures that have not yet been replaced. However, we have been able to accomplish some of the goals from the previous plan. We have established an exciting biophysics program through the appointments of Jaewook Joo (Theoretical biophysics) and Jaan Mannik (Experimental biophysics) and we have started the rejuvenation of the experimental condensed matter program with the appointment of Norman Mannella. Additionally we have made a Joint Faculty appointment of Raph Hix in Computational Astrophysics that has strengthened another emerging area. Finally we had a "failed" search in Fundamental Neutron physics, where the chosen candidate decided to stay at his current appointment and the other candidates did not fulfill our quality criteria.

Currently (AY2012) we are searching for two new faculty members: a search in Experimental Condensed Matter physics and a gender-diversity Target of Opportunity search, where the sekected candidate is Christine Nattrass in Experimental Nuclear Physics.

Based on the strategic principles outlined above and the substantial input from the faculty the following list of hiring priorities for the Department of Physics and Astronomy over the next 3-5 years has been developed:

**A. Top-tier hires (no priority assigned)**

Those hires are building on, and enhancing, existing excellence and provide exciting opportunities for the future

- A junior level position in Condensed Matter Physics theory
- A junior level position in experimental Condensed Matter Physics
- A junior level position in Fundamental Neutron Science
- A junior level position in Astrophysics

**B. Opportunity hires (strong cases have been made, but more work/information needed; no priority assigned)**

- A junior level position in computational nuclear physics theory
  - Strong focus on high-performance computing at UT/ORNL
  - Preference for Lattice QCD expert who will complement existing strength
  - Explore joint appointment with ORNL (Physics or Computing)

- A junior level position in low-energy experimental nuclear physics
  - New nuclear physics/isotope facility at ORNL, if built, will create exciting new opportunities in basic research and isotope science.

- A junior level position in Fundamental Neutron Science
  - Coupled to EDM experiment, if funded

- A junior level position in experimental HEP
  - Background in detector physics
  - Dependent on the advancement of Project-X at Fermilab and the discovery of the Higgs boson and New Physics at LHC.

- A position in energy research
  - Possible new opportunities through CIRE

- Positions in Physics Education
  - At the lecturer or assistant professor level for a person with general expertise in Physics Education.
  - A priority in 2006/2007 Departmental Strategic Plan

## C. Other possible hires

- Positions in optical physics affiliated with the Center for Laser Applications at the UT Space Institute
  - Two positions at the assistant or associate professor levels with expertise in optical physics and laser applications, broadly defined, including interdisciplinary physics
  - Funding would come from the UT Space Institute

# Long Range Plan – Contributions by Research Groups

Department of Physics and Astronomy
The University of Tennessee Knoxville
(Fall 2011)

## *Condensed Matter Physics*

Condensed Matter Physics (CMP) is currently one of the strongest and most exciting areas of research and graduate education in our Department and in the entire College of Arts and Sciences. The recent report of the National Academy of Sciences titled "The Condensed-Matter and Materials Physics: The Science of the World Around Us" lists the 8 most fundamental intellectual challenges facing condensed matter physics in the next decades. These challenges include:

- How do complex phenomena emerge from simple ingredients?
- What happens far from equilibrium and why?
- What new discoveries await us in the nano-world?

In parallel, the DOE BESAC (Basic Energy Science Advisory Committee) has identified five key "new era of energy" challenges and they include:

- How do we control materials processes at the level of electrons?
- How do remarkable properties of matter emerge from the complex correlations of atomic or electronic constituents and how can we control these properties?

These intellectual challenges not only define the forefront areas of CMP but are also at the heart of emerging material technologies related to electronics, data storage, information processing, quantum computing, energy storage and conversion, catalysis, and environmental clean-up. In light of the superb experimental and computational facilities at UTK/ORNL, we are ideally positioned to significantly advance the scientific stature and funding of our department, provided that we can reach "*critical mass*".

Unfortunately, the CMP group incurred several big losses in recent years. Profs. Ward Plummer (UTK/ORNL distinguished scientist), Rongying Jin (JFO), Victor Barzykin, Ted Barnes, Zhenyu Zhang (JFO), and Jim Thompson have left UTK and we have not been able to replace any of these people so far although a new search for the replacement of Prof. Thompson is currently underway. Rebuilding the group to its past strength requires hiring of at least four junior faculty, two in experiment and two in theory. Our most immediate priority will be the selection and hiring of a junior faculty in experimental CMP (underway) and approval of a new search in theoretical CMP. In addition, to further compensate for the recent losses in CMP, the two other positions must be vigorously pursued in the coming years.

The CMP group at UTK includes both theoretical and experimental components:

The theory effort includes Prof. Adriana Moreo, who is Joint Faculty with ORNL having UT as "mother" institution (JFU) (0.5 FTE), Prof. Adolfo Eguiluz (1 FTE), Prof. John Quinn (1 FTE, supported by the Chancellor's office), and Dist. Prof. Elbio Dagotto, JFU with ORNL (0.5 FTE, supported by Science Alliance), for a total of 3.0 FTE units.

The experimental effort includes Prof. Hanno Weitering, JFU with ORNL (0.7 FTE), Prof. Pengcheng Dai (1 FTE), and Prof. Norman Mannella (1 FTE), for a total of 2.7 FTE units. The recently approved search for a CMP experimentalist will move this number to 3.7 FTE, for a CMP total of 6.7 FTEs.

It is important to recognize efforts in other departments at UTK in the general area of CMP. Specifically, the programs carried out by Profs. David Mandrus, Veerle Keppens, and Takeshi Egami in Materials Science and Engineering (MSE) and Profs. Jan Musfeldt and Alexei Sokolov in Chemistry are very closely aligned with the interests of the CMP group. Together, we are united under the umbrella of the Functional Materials thrust in JIAM (technically speaking, other JIAM thrust areas such as the one on 'soft and hybrid materials' also fall under the category of CMP).

Materials research remains a top priority to the university administration. It all started under the leadership of Prof. Ward Plummer and the birth of TAML, which later morphed into JIAM. It would be highly beneficial to our department if the conditions for continued campus-wide leadership by the CMP group can be recreated through replacement hirings. It will be essential for the scientific stature of the department as a whole, as well as for our ability to raise external grants and improve recruitment of better students and faculty.

**Future research directions for the group**

The UTK Condensed Matter Physics group plans to focus in the near future on a broad theoretical and experimental effort to study a variety of interesting materials. This includes the emergence of complex collective phenomena in several compounds, with emphasis on the electronic component and the study of bulk and nanostructures, and on the use of both model Hamiltonians and *ab-initio* computational techniques. The projects described below take advantage of the proximity of Oak Ridge National Laboratory, and are aimed to maintain and enhance our group's leading international role in the general areas of Materials and Computers.

As already explained, the materials to be investigated in our effort are of considerable interest in the condensed matter and materials science community. The list includes *manganites*, where small magnetic fields drastically affect the transport properties and where multiferroic behavior has also been unveiled, *pnictides*, the recently discovered high-Tc superconductors based on Fe, and *cuprates,* the superconductors discovered in 86' that continue puzzling the CMP community. In addition, a variety of artificially created structures will be analyzed. This includes the study of thin films and super-lattices of transition metal oxides, a very active new area of research these days, as well as a variety of metallic quantum structures. The chosen materials of interest are in general characterized by having several simultaneously active degrees of freedom, providing a unique playground for theoretical studies, and the potentially for new functionalities and applications. Our current and future efforts address strongly correlated materials in general, and this also includes the analysis of the integer and fractional quantum Hall effect and other exotic low-temperature states, as well as transport in quasi one-dimensional systems of relevance in the analysis of quantum dots and molecules.

The scientific effort can be divided into several main areas of impact, and some of them will be here discussed in detail:

## (a) Study of Fe-based Superconductors.

In the last three years, an explosion of interest in high-Tc superconductivity has taken place after the discovery of a superconducting state with a maximum critical temperature of 56 K in a family of materials that have as common ingredient layers with Fe atoms as the active component, and As or Se acting as bridges between the irons. This discovery was totally unexpected since Fe is more often associated with ferromagnetism, being located in the middle of the transition metal row of the periodic table and having a large spin, as opposed to superconductivity. Several members of the CMP UTK group have already actively developed efforts in this field. Of particular relevance are the neutron scattering experiments of Prof. P. Dai and collaborators that reported the first neutron study that unveiled the magnetic order in the undoped parent compounds, and several other key contributions to the field. Prof. Mannella has made several key contributions towards elucidating the electronic structures and magnetic properties of these novel compounds, using soft-x-ray spectroscopies and angle-resolved photoemission (ARPES). The efforts led by Profs. A. Moreo and E. Dagotto on the theory side of the analysis have also led to considerable insight into the mechanisms for magnetic and superconducting properties of these compounds, remarking the "intermediate coupling" nature of these materials.

From the conceptual view point, the study of these compounds bring to the table the analysis of *multi-orbital* model Hamiltonians, as opposed to the widely considered single-orbital approach to the Cu-oxides. Having extra orbitals allows for an additional channel of complexity, and this manifests in the variety of spin orders that have been unveiled and on the possibility of competing superconducting states with different symmetries, as opposed to the clear dominance of only one channel (*d*-wave) in the cuprates. Having many orbitals provides a substantial challenge to all many-body techniques since the efforts (computational or analytical) rapidly grow with the number of orbitals that are active. This is actually an overarching conceptual issue that defines one of the research frontiers in this context: the addition of the orbital degree of freedom to the spin, lattice, and charge provide a variety of new channels of symmetry breaking that enlarge the list of candidate many-body ground states in this type of materials.

Although not presented here as an individual item, note that the study of the "old" high-Tc superconductors based on Cu is and will continue being a high priority of our group. The many analogies, as well as differences, with the superconducting pnictides will help us in better understanding the mechanisms behind these exotic superconducting states, hopefully in a unified manner.

## (b) Transition Metal Oxide Heterostructures

Experimental improvements in the growing methods have led to the artificial creation of superlattices made of transition metal oxides. This remarkable development establishes a new avenue toward the synthesis of new materials. Not only are the intrinsic properties of the components expected to be of importance, but also the periodicity of the man-made structure. Already novel properties have been unveiled, including metallic states at the interfaces of perovskite oxides that are both insulating. It is then conceivable that new phases of matter could be stabilized at the interfaces of oxides, for example via the local carrier doping of one material by the other at the interface, if they have different work functions. The study of the electronic properties of artificially made hetero-structures is one of the areas of interest of the CMP theory group. Note again that the building blocks of these structures are by themselves highly nontrivial, containing superconductors and magnetic states, so the possibilities for exotic behavior are many. On the theory front, calculations can be performed using a broad range of state-of-the-art techniques, including mean-field, dynamical mean-field, spin-wave, exact diagonalization, and Monte Carlo methods. On the experimental side, we are now ideally positioned to enter this exciting new area of research, due to the recent funding and purchase of a $1.3M oxide molecular beam epitaxy (MBE) facility, which will be coupled to a low-temperature scanning tunneling microscope (STM) and the existing ARPES facility (Weitering/Mannella). In particular, the capability of performing in-situ ARPES and STM on these novel oxide heterostructures is almost unique in the world and will alleviate many of the experimental uncertainties that have plagued this field. The new machine is expected to arrive in early 2012.

With the new MBE machine, we will also explore the potential of doped-transition metal oxide films for photo-voltaic and photo-catalytic applications. The emphasis here is to explore novel doping schemes (such as co-doping and modulation doping) for tuning the optical band gap and enhancing carrier mobility. There is a growing recognition that doped oxide thin films are indeed highly promising for energy research and as such, this line of research matches the core interests of JIAM and ORNL and should be highly fundable.

## (c) Quantum Design of Metallic Nanostructures

A third component of our scientific effort focuses on the emergence of collective phenomena and electrical transport in metallic nanostructures in the limit where quantum-size effects dominate. Here, the primary control parameter is the system size. Highlights include the establishment of extremely high supercurrent densities in thin films consisting of only a few atom layers, and the emergence of quantum-confined plasmon modes in monolayer thin films. The latter observation is directly relevant to the blossoming field of nano-plasmonics and in fact suggests the possibility of downscaling plasmonics even further toward the quantum-size regime. Future efforts along these lines will undoubtedly lead to novel discovery in diverse areas such as superconductivity, plasmonics, spintronics, and catalysis. It also opens up opportunities for acquiring the utmost control of the physical and chemical properties of these nanostructures via atomically precise control of thickness and quantum-mechanical boundary conditions.

## Relation with efforts at ORNL

ORNL focuses its research into Computers, Neutrons, and Materials, and for this reason it is advantageous for us to maintain a degree of coherence in our efforts with those at ORNL. The proposed list of areas of focus for the near future establishes a relation with efforts at the Materials Science and Technology Division, including the Thin Films and Nanostructures, Low Dimensional Materials Physics, and Correlated Electron Materials groups. Also a clear relation with the neutrons effort at HFIR is contained in our plans.

## Top Priority of the CMP group: Search for an Assistant Professor in Theoretical Condensed Matter Physics

The CMP theory group includes Profs. Moreo, Eguiluz, Quinn, and Dagotto. The theory group also includes many PhD students and postdoctoral assistants that are educated through their involvement in research and with the local (UT-ORNL) supercomputers. However, note that this theory component has recently been reduced in size after the departures of Profs. Victor Barzykin, Ted Barnes and Zhenyu Zhang. In view of the many opportunities in condensed matter theory described in part above, and its recent reduction in size, there is a consensus in the CMP group that the next hiring should be in CMP theory. A broad international search in this area of research is anticipated to bring several dozens of candidates, many with excellent credentials. The appropriate level will be Assistant Professor, with startup for the support of students and postdocs and computational infrastructure. With regards to the area of expertise our preference is to keep the search broad, without specifying a particular subarea of research within CMP theory, and then make final decisions based on the potential of the candidate as long as his/her area of expertise fits the existing efforts.

As already explained, the CMP theory group's research directions are broadly aligned with the NAS and BESAC reports, including the study of strongly correlated electrons, complex systems, nanostructures, and employing a variety of many-body techniques for both analytical and computational efforts. In the proposed search for a CMP theorist, candidates whose area of expertise fit within the topics mentioned above that are of current interest (particularly high-Tc superconductivity, transport in nanostructures, and oxide interfaces), and also in the already mentioned widely commented NAS and BESAC reports, will be given preference. It is clear that future directions of research and funding will be much influenced by those abovementioned reports, and as a consequence the successful candidate will be well positioned for a promising career if selected from the areas emphasized in those reports.

In addition, the national government in general, and the DOE in particular, are currently giving considerable importance to a variety of directions of research that are related with the production of energy, particularly via ``clean" techniques such as photo-voltaics. For this reason the relevance of the candidates' fields of expertise to energy investigations will also be of importance in our considerations of the candidates.

As a final remark, this hiring may be of relevance for the UT contribution to the National Institute for Computational Sciences (NICS), since many CMP theorists have expertise in computational techniques. In view of the fact that the UT Kraken Supercomputer is located in NICS at ORNL, the hiring of a CMP theorist that can take advantage of this superb computational resource will boost the departmental role within NICS/ORNL. Prospective graduate students typically find exciting the theoretical research that is carried out with the use of supercomputer, providing them with abilities that will make them marketable for future positions beyond CMP theory.

Finally, a second theory search (which we alluded to earlier in this document) should be requested as soon as possible. Again, the search should be broad and the selection of candidates will ultimately depend on the new realities at the time of hiring.

## Personnel Needs in Experimental Condensed Matter Physics

In mid 2011, a search for a junior experimentalist has been approved, compensating in part for the recent departures of Profs. J. Thompson and W. Plummer. In the current search, we plan to give strong preference to candidates whose areas of expertise matches the forefront areas mentioned above, and who are willing to become major players in the new UTK/ORNL Joint institute for Advanced Materials (JIAM). The new faculty member is anticipated to have expertise in one of the following areas: nano-transport, superconductivity, oxide-electronics, spintronics, plasmonics, batteries, and photovoltaics. The candidate is expected to take full advantage of the JIAM facilities, as well as the excellent facilities at ORNL (HFIR, SNS, aberration-corrected electron microscopes, CNMS nanocenter). Each of these areas complements the existing experimental and theoretical programs in a very significant way, and will strengthen our interactions with ORNL. The second search, which was also mentioned earlier in this document, should be requested as soon as possible. This search should also be broad and the selection of candidates will ultimately depend on the new realities at the time of hiring.

## *Nuclear Physics*

Nuclear physics continues to be one of the most active and important areas of science, both from a fundamental and an applied perspective. The field is broad and diverse in the questions it is answering and the challenges it faces on its many frontiers, as well as in its techniques and technologies. The intellectual drivers of nuclear physics can be captured by overarching questions that each span several of the traditional subfields of nuclear science, that each reach out to other areas of science as well, and that together animate nuclear physics today:

- How did visible matter come into being and how does it evolve?
- How does subatomic matter organize itself and what phenomena emerge?
- Are the fundamental interactions that are basic to the structure of matter fully understood?
- How can we best use the knowledge and technological progress provided by nuclear physics to benefit society?

Accomplishments since the last Departmental Long-Range plan have brought major progress toward answering each of these four questions, but each of them is multifaceted, broad, and deep, and in many respects the challenges posed by each question remain as opportunities for the decade to come. Because it sits in a liminal position between the fundamental and the emergent, between the microscopic and the astronomical, nuclear physics naturally addresses these central questions from varied angles, providing unique perspectives.

Over the last decade two new billion-dollar facilities in nuclear physics have started to operate (CEBAF at the Jefferson Lab and the Relativistic Heavy Ion Collider, RHIC, at BNL), and a third facility (the Facility for Rare Isotope Beams, FRIB) is on the horizon. In our own backyard in Oak Ridge, the Holifield Facility (HRIBF) continues to be the only ISOL rare isotope accelerator in the USA and plans are underway for a dual-purpose facility with the primary focus on medical isotopes. The Spallation Neutron Source (SNS) will have a strong component in nuclear physics with the programs in Fundamental Neutron and neutrino Physics.

The NP group at UTK includes both theoretical and experimental components:

The experimental effort includes Prof. Carrol Bingham (retired as of Aug. 2011 but scientifically active), Prof. Geoffrey Greene (JFU with ORNL; 0.5 FTE), Associate Prof. Robert Grzywacz, Assistant Prof. Kate Jones, Prof. Kenneth Read (JFU with ORNL; 0.5 FTE), Prof. Lee Riedinger, and Prof. Soren Sorensen, for a total of 5 FTEs.

The theory effort includes Prof. Witek Nazarewicz and Associate Prof. Thomas Papenbrock (JFU with ORNL; 0.5 FTE), for a total of 1.5 FTEs.

Current funding for this effort is provided by the research DOE grants through the Office of Nuclear Physics, Nuclear Energy, and National Nuclear Security Administration. The research of nuclear physics group at UT is extremely well aligned with the priorities and exciting opportunities in nuclear science. Greene is responsible for the Fundamental Neutron program at the SNS, Bingham, Grzywacz, Jones, Nazarewicz, and Papenbrock are among the leaders of the physics program at the Holifield facility (Nazarewicz is the Scientific Director of HRIBF) and other low-energy facilities worldwide, Read and Sorensen have major responsibilities in the PHENIX experiment at RHIC and at LHC. The group greatly benefits form the Joint Institute for Heavy Ion Research (JIHIR) at ORNL, which is a unique resource for low-energy nuclear physics. Bingham is a Director of JIHIR and Nazarewicz is a member of JIHIR Directorate.

## a) Low energy experimental nuclear physics

The long-term future of low-energy nuclear physics is tied to research at radioactive ion beam facilities, which provide previously unobtainable opportunities to study nuclei far from stability. The continuing developments and upgrades at current facilities where the group is operating at ORNL, ANL, and NSCL expand the range of species which can be studied, and allow more in-depth investigations on nuclei that have been observed previously only in small quantities. This is achieved through the expansion of rare isotope production and acceleration capabilities and the development of new, more capable instrumentation. The development and application of new ultra-sensitive detection techniques is where the UTK group strength is and will be in the future. The main physics questions in both fundamental and applied research, addressed by the group, are:

- What are the limits of nuclear stability?
- What are the new exotic features for nuclei far from stability?
- How do these nuclear structure effects influence astrophysical nucleosynthesis?
- How should the nuclear properties of fission products influence the design and operation of nuclear reactors?

The experimental nuclear physics group at UTK will play a major role at the future Facility for Radioactive Ion Beams (FRIB) at MSU, provided that the necessary resources are in place. Below we discuss future research directions for the group at currently existing rare isotope facilities.

**Comprehensive studies of beta decay for nuclei far from stability**
We are currently involved in building and commissioning of new high performance detectors, which will be used to study very neutron-rich nuclei. One purpose of these studies is to discover what amount of the decay energy from radioactive nuclei is produced in the form of charged particles, gammas or neutrons. This is essential to test microscopic models of beta decay, which can predict lifetimes for nuclei that existed only in explosive stellar environments but led to the formation of heavy elements. These measurements, carried out on less exotic fission products, will provide essential data for modeling of new nuclear reactor systems. We have proven in recent research that isobaric separation capabilities and modern detection techniques can provide much higher quality data than measured before.

Presently in collaboration with institutions gathered in the Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science, we are developing new a multi-detector for neutron energy measurements, called VANDLE, which will be used in future experiments at ORNL and NSCL. Another large detector, which is currently being developed is MTAS — a high-efficiency calorimeter to measure the part of the decay heat that is emitted through gamma rays. Both projects will rely on the digital data acquisition systems development led by the UTK group.

**Limits of nuclear existence**

We continue our research on two-proton emission from exotic nuclei. We intend to continue the charged particle decay studies of the fastest alpha emitters known. The experience gathered through these studies, where we have developed a unique data acquisition system that can perform measurements without dead-time losses, can be applied in superheavy element (SHE) research. SHE synthesis has recently picked up momentum through the successful application of transuranic targets. These measurements will be made at JINR Dubna and GSI Darmstadt using their efficient gas-filled separators.

These are the main research thrusts for our group in the next few years. We hope to successfully continue our partnerships with scientists in National Laboratories.

We continue educating graduate students, who can be trained both through the construction of the new devices and through participation in experiments at research facilities. The low-energy nuclear physics group has the ability to thrive at the University of Tennessee because of the continuous interactions with the very strong nuclear theory group and the researcher community centered at Oak Ridge National Laboratory. The proximity of ORNL significantly enhances the research experience of our students and also leads to more complete training in experimental nuclear physics.

*The on-campus activities* involve the development of detector and electronics systems. We also have capabilities to store and analyze large data sets collected in experiments.

Our research will benefit from the discussed upgrade of the nuclear physics/isotope facility at ORNL, which will likely involve a new driver cyclotron. Indeed, the decision of the DOE to incorporate the nation's isotopes program in the Nuclear Physics Program Office brings many interesting opportunities to UTK, including a possible hire in this area. *There is a consensus within the nuclear physics group that we should be prepared to move quickly if the construction of an isotope facility at ORNL is approved.*

## b) Reactions and Nuclear Astrophysics Experiments

The low-energy nuclear physics group has strengthened its position in reactions and nuclear astrophysics considerably in the last 4-5 years. Most of this has occurred through a close collaboration with the nuclear astrophysics group at ORNL, and to an increasing degree, the reactions group. In particular, the UTK group has played a leadership role in the successful transfer reaction program at the HRIBF, notably in the $^{132}$Sn region. These efforts are highly integrated into the research program within the physics department, being connected with theorists in both nuclear physics and astrophysics. Additionally, this research is highly aligned with the NSAC long-range plan, making major impacts on milestones for both nuclear structure and nuclear astrophysics.

Importantly, UT graduate students have been key to instrumentation projects at the HRIBF. In preparation for a new large, highly segmented silicon array (super-ORRUBA), work integrating a new integrated circuit based acquisition system into the ORNL data acquisition system has been led by a UTK student. This work is vital to the actualization of super-ORRUBA, which will have in excess of 1000 channels. UTK students have also developed designs for a fast ionization chamber, detector mounting systems, and beam monitoring detectors. These development projects are often integral to thesis projects. Undergraduates from physics and engineering departments have played key roles in both research and development projects, some which cross the borders of nuclear physics with astrophysics, and theory with experiment.

The near-term future will be focused on opportunities at the HRIBF using both fission -fragment and proton-rich rare isotope beams with new tools such as super-ORRUBA and the helium gas jet target. A new program of research based at the NSCL using knockout reactions to study the ground states of exotic light tin nuclei begun in 2011. In the long term, UT is expected to play an important role in FRIB, especially in the area of direct reactions.

## c) Low energy nuclear physics theory

The low energy theory group is led by Nazarewicz and Papenbrock. There are typically 6 postdocs, 7 graduate students, and several visitors involved in current research. The group's research directions focus on a much-improved understanding of atomic nuclei across the nuclear chart and are well aligned with the NSAC Long Range Plan. Existing experimental facilities in the USA and abroad provide us with data on rare and very short-lived isotopes that continues to challenge low energy nuclear theory. Future facilities such as FRIB and similar investments worldwide will challenge theory even further. We are benefitting from collaborations with our experimental colleagues at UTK and ORNL and from excellent access to supercomputers (such as UTK's Kraken and ORNL's Jaguar) and various resources in high-performance computing. In particular, we are leading the SciDAC-2 UNEDF project — a national collaboration of nuclear theorists, computer scientists, and applied mathematicians, which aims at creating a comprehensive computational framework describing all nuclei.

We are involved in, and lead, many national and international collaborations. We direct both JUSTIPEN (the Japan-US Theory Institute for Physics with Exotic Nuclei) and FUSTIPEN (the French-US Theory Institute for Physics with Exotic Nuclei), which are administrated through the JIHIR.

The theory group educates and trains undergraduate students, Masters students and PhD students. We involve them in all areas of research, both analytic and computational. We note that several of our students perform part of their work on Kraken and Jaguar supercomputers.

*The field of computational nuclear theory continues to grow. The hire of a theorist in computational QCD should be considered a high priority in the case that a vacancy arises at UT in this research direction.*

Lattice quantum chromodynamics (LQCD) is a major area of computational research in theoretical nuclear and high energy physics (NP and HEP). In LQCD one uses supercomputers to extract predictions from the theory of the strong interaction (QCD), which describes the strong (nuclear) force in terms of the interaction of quarks and gluons. Although the theory of QCD is well defined mathematically, the strength and form of the interactions make analytic solutions essentially impossible. Recently, “Monte Carlo” numerical techniques using supercomputers to study QCD on a space-time grid or lattice (hence “lattice QCD” or “LQCD”) have become very effective at solving this type of problem, and lattice QCD studies now constitute one of the major activities in theoretical nuclear and high energy physics. To date the applications of LQCD have primarily been concerned with NP at medium and high energies (hadron spectroscopy, and heavy ion collisions / quark gluon plasmas) and in HEP with weak interactions (matrix elements for CKM studies). Future growth areas of this research include low energy NP (nuclear forces and the nuclear equation of state, “EOS”), and applications of these methods to new quantum field theories in HEP “beyond the standard model”.

Several aspects of the UT/ORNL research community argue strongly for the development of a research program in the area of lattice QCD. One is that ORNL has become a leading national laboratory for computationally intensive research, including being the site of the world’s fastest supercomputer. Since LQCD is recognized as one of the leading topics for computational research in nuclear and high-energy physics, the prospect of participation by the UT/ORNL physics community in this area is very attractive. Another favorable aspect is that UT/ORNL already has a very strong program in low energy nuclear physics, including world class groups in nuclear structure and nuclear astrophysics; an LQCD group involved in the study of nuclear forces and the nuclear EOS would have an excellent opportunity to align their research goals with the existing nuclear theory program at UT and ORNL. Finally, students find this type of theoretical “supercomputer” work very exciting, so the existence of this program could be an enticement in recruiting strong graduate students.

There is a consensus within the nuclear physics group at UTK that the department should proceed to seek a hire in the general area of computational QCD. The case for such a position has already been made: it would complement the department’s theory activities and computational efforts at ORNL, and would appeal to DOE in that it would be perceived as “filling an opening” at UT/ORNL. Several excellent junior candidates for a joint faculty position were mentioned. Consideration of likely candidates for a LQCD hire suggest that the appropriate level might initially be at the Assoc. Prof. level, with some initial startup support for graduate students and infrastructure. The fact that many of the active researchers in this field are early in their careers suggests that one could establish a very effective LQCD group with a moderate level of support.

## d) Fundamental Neutron Physics

The study of nuclear and particle physics ("fundamental neutron physics") using low energy neutrons continues to provide an extraordinary opportunity for UT due to the presence of the SNS at ORNL. The fundamental neutron physics beam line at the SNS is now operational and the first experiments are in the process of being installed. The proximity of the SNS to Knoxville provides excellent opportunities for campus-based experimental research. Since the ORNL will be focusing on experimental efforts, UT also has the opportunity to establish leadership in nuclear theory in this area. Since SNS will be the new national (and ultimately world) center for this research UT has an opportunity to seize leadership in this field.

*In order to become a world leader, UT must establish a research group with a critical mass of ~3 FTE faculty in this area.*

These faculty must be judiciously selected for their ability to interact productively with ORNL and with existing nuclear and particle groups at UT. A recent search identified an excellent junior candidate who declined an offer. The open position was then lost in the financial squeeze of 2009.

At present there is only one senior faculty (Greene) in this field at UT. Unless succession planning is made this unique opportunity will be lost.

The recent high priority given by the Nuclear Sciences Advisory Committee and subsequently by ORNL physics division to this field suggests that the possibility of a hire would be an appropriate response to this opportunity and that such an action would be viewed favorable by ORNL and funding agencies. We should move with all deliberate speed to identify possible candidates.

## e) Relativistic Heavy Ion Physics

The field of relativistic heavy ion physics has been one of the most exciting fields in science over the last decade. The discovery at RHIC of the Quark-Gluon Plasma, announced in 2005 through the simultaneous publication of white papers by the four experiments, PHENIX, STAR, BRAMHS, and PHOBOS, has been one of the scientific highlights of science. The plasma has turned out to have completely different properties than what was originally envisioned. The plasma is strongly interacting (more like a liquid than like a gas) and with the lowest specific viscosity (viscosity/entropy) of any material ever found, including superfluid helium. Furthermore, a speculative, but very exciting, connection between the plasma and black holes in the ADS/CFT correspondence seem to have provided strong interaction physics with at least a new tool.

The two large experiments at RHIC, PHENIX and STAR, are currently undergoing large upgrades, so they will be competitive for another decade, and at the same time more advanced plans for a complete rebuild of one of the detectors, or maybe a completely new detector, are being discussed. At CERN the Large Hadron Collider is now working flawlessly, and will provide data for at least the next decade for the dedicated heavy-ion detector, ALICE. On a time-scale of a decade or more, there are serious plans for a heavy ion – electron collider. So the field is extremely active, and the opportunities for exciting science for several decades — very good.

The RHIP (Relativistic Heavy Ion Physics) group at UT consists of Sorensen and Read. We have had a stable DOE grant since 1996. We typically have one post-doc and 2-4 students. However, recently the student interest has been overwhelming and currently we have 5 graduate students in the group. We have been collaborating with the HERG (High Energy Reactions Group) in the Physics Division at ORNL for more than 25 years, and this collaboration has enabled us to participate in more experiments and construction projects than what our small 1.5 FTE university group could indicate. We are active in PHENIX and ALICE as well as in some of the more interesting upgrade plans for both detectors.

For the last couple of strategic planning processes the RHIP group has not requested any positions, but with the great activity in the field and the need for a high-profile PI in 5-10 years, when Soren will retire, to secure our contract, we feel strongly that it is now time to renew the group. We are suggesting this to happen in the following way:

a) UTK has over the last two years had a program for special diversity hires. These positions have come without any negative feedback for other position requests. We have an outstanding candidate in Christine Nattrass, who is our current post-doc. She is not only a great and very high profile physicist with a Ph.D from Yale, but she is also a very active advocate for gender diversity in Physics. For example, she will be the host of a conference here at UT in 2012 for Undergraduate Women in Physics. I (=Soren) was on the selection committee for these diversity hires in 2010 and based on that experience I think we will have a very large chance of being able to hire Dr. Nattrass through this process without any negative influence on other search requests.

b) The HERG group at ORNL has lost its two leaders over the last couple of years. Division Director Glenn Young left for a position at JLAB, and Vince Cianciolo is now 90% engaged in the EDM experiment. We have therefore started discussions with ORNL for hiring a Governor's Chair in this field, who can be the new leader of the HERG group and, in particular, secure large-scale construction funding to ORNL (and UT!). A particular candidate has been identified, who is likely to be the next spokesperson for PHENIX. However, securing a hire in a Governor's Chair position is difficult, so whereas we will very actively pursue this opportunity, I am not overly optimistic about the final outcome.

### *Soft Materials Physics*

I *(Sokolov)* consider Physics of Soft Materials as a very important emerging area in the field of Materials Physics. The level of complexity in the Soft Materials physics is very high and the field relies on many phenomenological models and theories, on very crude approximations. However, it presents an exciting emerging area with very fast growth. Soft materials, including polymers, colloidal and glass-forming systems, supercooled liquids and biological systems are finding larger applications areas in all aspects of our life.

Regarding the department, the soft matter field can focus on applications of soft materials to energy problem. This way it will have a direct connection to the DOE mission and will increase collaboration with ORNL.

- The existing opportunities are broad, from organic photovoltaics with traditional problems of charge separation and electron/hole conductivity, to membranes for batteries and fuel cells with the problems of high ionic conductivity. With ORNL and Chem. E and Materials Science and Eng. Departments at UT we might be leaders in some aspects of soft matter physics.
- Training of students in emerging area, especially related to Energy should be very attractive for students. They also might use unique facilities at ORNL (computational, neutron scattering, etc.).
- Will work perfectly for all the mentioned organizations, including Joined Institute for Advanced Materials, etc.
- I see plenty of opportunities for funding of this research from DOE and NSF. Also DOD and AFOSR might have significant interests.

## *Biophysics*

Complexity of the phenomena in biological systems is much higher than in other topical areas. Approaches originating from Physics, especially from Statistical Mechanics and Condensed Matter theory, have started to provide some of the key concepts in describing and understanding these phenomena. Moreover, experiments in Life Sciences are becoming more and more quantitative and Physics plays crucial role in this development.

Biophysics is **must** for any current Physics Department that wants to attract good students. We have two full time faculty (Jaewook Joo, Jaan Mannik) working in Biophysics now. The number of Biophysicist in the Department is yet too small to be highly visible and attractive for students nationwide. It appears that in addition to these two faculties there are many UT professors scattered among various Departments who are actively involved in biophysics research. We think the Physics Department should take a lead in consolidating various Biophysics efforts and create an interdepartmental program/initiative in Biophysics.

- There are many exciting opportunities in Biophysics area. We can benefit tremendously from the presence of ORNL with their supercomputers, neutron scattering and micro/nanofabrication facilities. There are also many possibilities for mutually beneficial collaborations with the researchers in the Biosciences Division at ORNL. This might bring to UT options, which are not available for other universities.

- Biophysics will attract many talented students to the Department and increase its visibility.

- We see tremendous opportunities for interactions with many colleagues on campus on various topics in Biophysics. NIMBioS, joined institutes for computational sciences, and for neutron sciences, Center for Computational Biophysics will be actively involved. We also carry out active collaboration with researchers from Biochemistry and Cellular and Molecular Biology (BCMB) and from Center for Environmental Biotechnology (CEB) at UTK.

- Funding opportunities should be reasonably good from NSF, NIH and DOE (on bio-energy related topics).

- There are many biophysicists on campus, scattered across many departments whose research may get boost from access to interested students with a relevant background. This should help us to create a reasonable Biophysics program in a rather short time with limited resources.

## *Experimental HEP group*

**Overview**
High Energy Elementary Particle Physics today is in a similar situation to that before the revolution in physics with the introduction of special relativity by Einstein and the formulation of Quantum Mechanics. On the forefront research in fundamental forces and particles, this year we are poised to learn about the way mass is created by finding the Higgs boson with the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland, or by significantly excluding the presence of the Higgs boson, and to potentially observe effects from unknown forces. Last year this field garnered worldwide attention with the first evidence for the presence of the Higgs boson in two independent experiments at LHC, with one of it being the CMS experiment, in which our group has been a collaborator since 2006. While this project is expected to continue for the next ten years the outcome will soon spawn new generations of experiments for precision studies of observed evidences. The recent controversial result from the OPERA collaborators who claim neutrinos travel faster than the speed of light in vacuum that received so much attention in the mass media has to be tested by several experiments, one of them is NOvA in which the HEP group is participating. Fundamental questions such as why there is a deficit of anti-matter in the Universe will potentially be answered by the neutrino experiments that have just come online or are about to come online, such as the Double Chooz experiment in France and the NOvA experiment at FNAL, and by measurements at the LHC at higher energies and luminosities, as well as the future experiments at FNAL with the proposed Project-X. The question: “What constitutes Dark Matter in the Universe?” might be answered with LHC and has already triggered a series of Dark Matter Search experiments in the rapidly emerging field of Astroparticle Physics that is closely intertwined with HEP. In neutrino physics and physics at the LHC our group has demonstrated leadership and generates high visibility for the University of Tennessee in international collaborations and attracts students at undergraduate and graduate level to participate in research and choose UTK as place to graduate.

**Detector Research**
The search for new phenomena in unexplored intensity and energy regimes requires the development of novel detection technologies. Our group is leading in photo-detector development for Cherenkov and scintillation detectors, and recently, motivated by the need for radiation hard charged particle detectors for LHC, started working on the application of artificial single- and poly-crystalline diamonds as such detectors. In our laboratories at the UTK campus together with undergraduate and graduate students we develop and study particle detectors starting from prototype versions to final implementations in large-scale detectors. This activity creates synergy between our group and other departments at UTK such as the Nuclear Engineering and the scintillator research lab. We collaborate with groups from and use facilities at ORNL, for example for the study of neutron targets for FNAL’s Project-X and the radiation hardness of diamond under neutron irradiation. Efforts in detector research are coordinated between our group and groups from other institutions such as Berkeley, Princeton, Rutgers, Stanford, Vanderbilt, Boulder, FNAL and JLAB to name some of the US institutions, and internationally we collaborate with CERN, KEK/Japan, Zürich/Switzerland, Vienna/Austria, DESY/Germany, ILL/France, and VECC/PRL in India. We propose, manage, and conduct small scale beam test experiments with prototype detectors at FNAL, CERN, and ORNL. Particle

detectors that are developed for HEP can potentially also be applied for other applications such as medical imaging and homeland security. There is a long history between this group and the IEEE, and we have continuously presented and been recognized at IEEE conferences.

**High Performance Computing**

The enormous amount of data produced by accelerator experiments requires large scale computing and fast network connections. The key is distributed computing that makes use of resources world wide that are linked by the so-called GRID. We have developed a GRID site at the university. As spin-off of our group's collaboration with OIT and Chemical Engineering the university implemented the high-performance computing cluster (Newton cluster) in the Metron building. Its architecture is based on the (free) software developed in HEP. The effort is lead by Mr. Gerald Ragghianti who graduated from our group. The LHC group at UTK together with OIT also installed an ultra-fast (10GBit/s) prototype network switch that connects via a dedicated fiber network to the starlight facility in Chicago. Furthermore, we collaborate with OIT on the next generation internet implementation for the campus. The computing infrastructure at UTK gives us an important advantage in pursuing challenging data analyses that lead to publications. The Newton cluster has now become attractive to many researchers at the UTK campus, such as groups from Chemistry Computational Biology, and several of our colleagues at Physics and Astronomy. It also serves as a developmental lab for algorithms before they are run on the super computers located at ORNL.

**Funding and Personnel**

The HEP experimental group is involved in the DOE HEP flagship directions of research. According to the vision of the HEP community and DOE (http://www.er.doe.gov/hep/vision/) the three main HEP directions of research are defined as "energy frontier", "intensity frontier", and "cosmic frontier". At the "energy frontier" the group is a collaborator in the CMS experiment at the LHC, and at the "intensity frontier" the group participates in NOνA, Double Chooz, LBNE/DUSEL, and KamLAND neutrino experiments, and in the BaBar electron-positron collider experiment. The funding within the last 3 years exceeded $1M, and was listed in the top 20 funded groups by the UTK Office of Research. For the last 41 years the group has been continuously supported by DOE's Division of High-Energy Physics. For over 20 years the group's funding has averaged in excess of $500K per year and has increased to over $700K in the last two years. Currently the HEP group consists of 3.5 faculty members: Tom Handler, Yuri Kamyshkov and Stefan Spanier who are full time faculty, and Yuri Efremenko who has a 50% joint appointment with ORNL. Dr. Efremenko has recently received an additional DOE funding for his work on the Majorana experiment. At present, the group supports 4 postdocs and 7 graduate students and in the last ten years produced at least 65 significant research publications with citation index greater than 100. Involvement of undergraduate students has also benefitted from the support by the Office of Research for example for travel to international laboratories and meetings.

**Hiring**

To build on our strong involvement in detector development, to further foster collaborations and synergies between departments at UTK and make stronger use of the expertise and facilities at ORNL we urgently need a faculty member that has a strong record in particle detector development. The candidate needs to be involved with ongoing experiments, and have a clear vision for involvement in future accelerator or earth or space-based Astroparticle Physics experiments. Such a faculty will not only enhance the standing of the HEP group but will easily collaborate with faculties across the Physics department as they use particle detectors in their research such as experimental Neutron and Nuclear Physics. The development of detectors is well funded by DOE via base funding, but also with dedicated awards. Furthermore, the NSF program provides several opportunities, among those the award for five years that is converted to continue funding from DTRA, and the MRI award. Homeland security (DHS) provides several grants for the study of particle detectors for radiation safety.

Apart from the immediate need for strengthening our effort, the experimental group is about to face a manpower crisis. Two faculty members of the group are near retirement age: Dr. Kamyshkov is 65 and Dr. Handler is 64. Thus, the HEP group is in danger to become seriously depleted and will be unable to maintain the current high profile of effort and DOE funding. To provide continuity of effort and funding it will be necessary to initiate the replacement of Dr. Kamyshkov and Dr. Handler by junior faculties.

**Summary**

To guarantee the success of the HEP group in the department and continue DOE funding, and to capitalize on our growth potential with increased manpower, we must at the minimum, hire 2 Assistant Professors in the HEP group.

## *High-Energy Theory*

The high energy theory group consists of George Siopsis (Professor) and his students. The group is funded by the DoE and funding has been steadily increasing over the years. The productivity over recent years has been very high with several publications each year. High Energy Theory has been consistently attracting some of the best and brightest PhD graduate students in the Department. Currently, there are 6 students pursuing their PhD in High Energy Theory at various stages in their graduate studies. Our research is computationally intensive involving both symbolic manipulations (based mainly on Mathematica) and numerical analysis. In this endeavor, we are taking advantage of the computing power being built for the group with support from UT (we have been awarded 2 computational servers and shares in the multi-processor Newton Cluster, including installation of multi-processor Mathematica, which substantially increased our computing capacity).

The research focuses on 2 main areas:

1) Fundamental interactions at the Large Hadron Collider (LHC). The LHC is exploring a new energy frontier and is expected to answer fundamental questions such as the origin of mass, nature of dark matter and perhaps dark energy, physics beyond the Standard Model, etc.
2) Application of the gauge theory/gravity duality to strongly coupled physical systems, such as the quark-gluon plasma produced in heavy ion collisions (RHIC, LHC) and materials such as superconductors and superfluids.

   The high energy theory group used to have 2 faculty members and was reduced by 50% a few years ago. It is important for the Department to add a theorist in high energy physics, especially one who specializes in phenomenology (fundamental interactions, physics beyond the Standard Model physics, neutrinos, etc.) who can take advantage of opportunities in all 3 HEP frontiers (energy, intensity and cosmic frontiers), support the experimental effort and enhance the theory group's funding potential.

## *Theoretical and Computational Astrophysics*

Astronomy, Astrophysics, and Cosmology (AAC) represents one of the most active and visible fields in modern science, with problems such as the mechanism for both core-collapse and thermonuclear supernovae, gravitational wave emission, origin of the elements, dark matter, dark energy and the accelerating Universe, gamma-ray bursts, neutron star and black hole mergers, the role of neutrinos in astrophysical phenomena, and the nature of black holes appearing near the top of any list of major unresolved issues in all fields of science. It is also relatively unique in being one of the easiest fields to promote to the public because of the fundamental implications of its subject matter for origins and our place in the Universe, and the often-stunning visual imagery that accompanies it.

### The Local Effort

The local AAC effort is a joint one between ORNL and UT. The leading staff members are Tony Mezzcappa, Bronson Messer, Raph Hix, Christian Cardall, and Eirik Endeve based primarly at ORNL, and Mike Guidry, based primarily at UT (with Hix 50/50 between UT and ORNL, and almost all staff having some form of dual UT/ORNL affiliation). We presently have 3 postdocs, 4 doctoral students, and several undergraduate students doing research with us, as well as a strong adjunct contribution from Jirina Stone at UT and ORNL. At ORNL, we are aligned with both the Physics Division and the Computational Science and Mathematics Division.

### National and International Significance

The importance of AAC has been recognized in various reports of strategic scope. Our research is well aligned with several aspects of the NSAC Long Range Plan, the Astro2010 Decadal Survey, etc., and with various mission statements of the DOE, NSF, and NASA. It has been recognized also in funding levels enjoyed by the theoretical astrophysics group, since we have substantial funding from three agencies, DOE, NASA, and NSF, and in competitive awards of computational time on the largest machines: We are among the leading computational efforts at the OLCF (among the top INCITE awards since the inception of the program in 2004), and AAC as an area is among the leaders in awarded time at both the OLCF and NICS.

### Synergism and Leveraging of World-Class Facilities

Our AAC effort is highly synergistic. It connects with the experimental efforts in both nuclear and particle physics in the Department, with the theory efforts in both nuclear and particle physics in the Department, with the experimental, theoretical, and computational efforts at ORNL, and with other departments on campus, most notably EECS. As noted separately, we play a leading role within the advanced computational community in the drive to exascale computing, both in terms of strategic vision and in terms of example.

Our group concentrates on a range of astrophysics problems that are at once leading-edge science and leading-edge computation: core-collapse supernovae, Type Ia supernovae, neutrino astrophysics, neutron star mergers, gravitational wave emission from core-collapse and mergers, the role of magnetic fields in collapses and mergers, the astrophysical sites for origin of the elements, the microscopic behavior of matter under the most extreme conditions known in the present Universe. This choice of subject matter and our approach to it represent highly effective leveraging of unique local resources. ORNL and UT have two facilities agreed across the board to be world class in stature. The Spallation Neutron Source is one such facility; its unique capabilities have been used---with good reason---to justify a number of University and Department of Physics and Astronomy hiring and policy decisions. The computational facilities operated by ORNL and UT (led by Jaguar and Kraken, and soon Titan) are no less world-class in stature, but this has had much less impact on past Departmental policy and hiring. It is not prudent to continue to neglect this resource, particularly in light of (1) recent indications that enhanced supercomputing will ascend to even higher national priority than it presently has, and (2) a broad recognition that computational astrophysics is a primary driver in the international race to exascale computing and that our group is at the forefront of this effort in both expertise and leadership.

**Educational Contributions**

AAC is vital for the educational health of our Department. The introductory astronomy courses generate critical student credit hours and represent the only brush with modern science for many University students, our honors astronomy 217-218 course is popular with students from many departments, our upper-level 411 and 490 undergraduate and 615-616 graduate astrophysics courses invariably attract some of the largest enrollments of all upper-level courses within the Department, and perceived strong astrophysics is a major student recruiting incentive at both the undergraduate and graduate levels. The theoretical astrophysics group has been responsible directly or indirectly for much of the success of all of these endeavors.

Over the past years, the astrophysics group has also been one of the leading Departmental groups in the research training of undergraduate, Master's, and Doctoral students, as measured by sheer numbers, quality of students produced, and the professional success of those students. Several of our undergraduate students have won major University research awards and gone on to prestigious graduate schools, and every MS and Doctoral student that we have graduated over the past decade is presently employed in astrophysics, teaching of the sciences, or high-performance computation in fields other than astrophysics.

**Future Efforts**

On a 5-year timescale our group will continue present efforts and expand aggressively into several new areas. Likely major areas of emphasis will be

1. State of the art computation for the core-collapse supernova mechanism.
2. Expansion of our emerging effort in the Type Ia supernova mechanism.
3. Gravitational wave emission and detection signatures from core-collapses and neutron star mergers.

4. The role of magnetic fields in collapses and mergers.
5. Detection signatures for neutrino emission from core-collapse supernovae.
6. The next generation of astrophysics codes for the exascale.
7. Systematic elucidation of the origin of the elements.
8. Understanding the equation of state for dense matter (neutron stars) and hot dense matter (supernova cores).

**Hiring Priorities**

We have accomplished everything listed above with only 1.5 FTE faculty in theoretical astrophysics at UT (Guidry at 1.0 FTE and Hix at 0.5 FTE). Such an effort should be rewarded, at least modestly. Our Departmental hiring priority is a full-time new faculty member in a discipline related to, but not identical to, what we already do. For example, a computational person with expertise in gravitational waves and applying full general relativity to the core-collapse and merger problems, with strong connections to LIGO and other components of the gravitational physics community, and having excellent teaching credentials, would be a superb fit. The right choice would enhance strongly both the research and educational interests of the Department, and there are known candidates fitting this description who would find a position with us to be attractive.

In addition, we shall in parallel pursue game-changing strategies with the potential to generate new faculty lines outside the usual channels such as a Governor's Chair level appointment, an NSF Science and Technology Center, and leveraging of the leadership role being played by computational astrophysics in general and our group in particular in the intense and now-global race to the supercomputing exascale. A Departmental commitment to a new faculty line as described above would be a huge direct and indirect asset in our efforts to obtain an NSF Science and Technology Center (such a center would bring $25M of funding over five years, potentially $50M over ten years). In the last competition, we made the cut to the final 20 out of more than 300 submissions across all disciplines (5 were finally awarded). If we had been successful, this would have been the largest external scientific research grant in U. T. history, and would have generated 5 new faculty lines in Physics and Astronomy. Obviously, obtaining such a Center would have an unprecedented positive impact on the general academic, research, and computational ethos of the Department and University, and represents a worthy strategic goal for our Department.

## *Energy-related research*

The university has initiated a new interdisciplinary doctoral degree in Energy Science and Engineering (ESE), to begin with the first class of 20 to 40 new graduate students in the fall of 2011. Since this is an interdisciplinary degree, it is administered in the newly created Center for Interdisciplinary Research and Graduate Education (CIRE), a joint center between UTK and Oak Ridge National Laboratory. Lee Riedinger was appointed as the director of this new center on September 1, 2010. Soren Sorensen served on the Task Force that made the detailed plan for the ESE degree and for CIRE, and continues now on the CIRE Board of Directors.

*Energy science and engineering* is an emerging field of study that builds on the conventional disciplines of science and engineering but is focused on the challenges and issues relating to the development and use of sources of energy. The issues of energy supply and use provide our country and the world with some of the grandest challenges that citizens and institutions face now and for coming decades.

A few new courses will be offered at the 500 level, while existing 500 and 600 courses in various departments will be utilized to provide the course component of the PhD, which differ depending on the specific area of specialization of the ESE student. The proposed ESE PhD will offer coursework that serves two purposes - (a) a broadening education in the issues of energy generation and use from many aspects and (b) a deep dive into issues of energy in a given discipline. The students will work on doctoral research in one of six initial areas relating to energy in multi-disciplinary teams of scientists and engineers working at the university and the laboratory. Some students will choose to include entrepreneurial elements in their program of study, working with faculty from the College of Business Administration. All students will receive a broad foundation of coursework and doctoral research in teams working at the forefront of the science and engineering related to energy. The six initial areas of research in the ESE program are:

1) Nuclear energy
2) Bioenergy and biofuels
3) Renewable energy
4) Energy conversion and storage
5) Distributed energy and grid management
6) Environmental and climate sciences related to energy

CIRE ESE students may also choose to pursue a conventional doctorate in one of these six areas of energy-related research, working in an appropriate department and taking some of the ESE courses to earn a *concentration* in ESE. The Physics Department is establishing this graduate concentration for the coming academic year.

CIRE has no faculty lines and will operate with the help of existing researchers at UT and ORNL attached to the ESE program. The first set of 38 faculty was appointed by the Provost on December 20, 2010, and includes Witek Nazarewicz from Physics, by virtue of his connection with the nuclear energy track in the ESE degree program. It is anticipated that some of the materials faculty in Physics will become CIRE faculty in the future.

This new doctoral program offers opportunities for the Physics Department to expand its areas of research into fields that closely relate to the energy needs of the country. Current department research directions already strongly overlap several of the above areas of ESE energy-related research, e.g., in the understanding of nuclear fission processes and of hydrogen storage strategies. The Physics Department needs to look for increased opportunities to do research, seek funding, and perhaps even hire new faculty in areas related to *energy science and engineering.*

## *Educational and staff positions*

The Department of Physics and Astronomy delivers a large number of student credit hours (SCH) through our general education astronomy classes (Astronomy 151, 152, 161, and 162) and physics classes (Physics 101, 102) as well as our many service courses for other departments and colleges (Physics 135, 136 for science departments, Physics 161 for Architecture and Interior Design, Physics 221, 222 for Biology, and Physics 231, 232 for Engineering). In particular, the astronomy classes are popular, but also difficult to teach. Historically the department has been served well by having long-term employed lecturers, like Tina Riedinger and Steve Daunt, teaching these classes with a high level of dedication and attention to the students. However, Tina Riedinger retired nearly 10 years ago and Steve Daunt can be expected to retire in the near future. Considering that Steve Daunt typically teaches 6-7 astronomy classes annually, his retirement will leave the department in a position, where it will be difficult for us to meet our teaching obligations. Historically we have also found that these long-term, high dedicated lecturers provide a much better educational experience for the general education students than "normal" physics professors, who do not have time to interact with more than 400 students each semester through email, Blackboard, and personal contacts if they also are required to supervise several graduate students as well as carry out internationally renowned research.

Upon Steve Daunt's retirement it will therefore be necessary for the department to retain his line-item position in order to hire a new, dedicated lecturer to be responsible for a large part of our educational astronomy program. This new hire will also be expected to be responsible for educational astronomy labs as well as the educational content of our new Planetarium. It will essentially be the Astronomy Coordinator that was identified by a departmental astronomy task force a few years ago as a high priority item for our department.

Similarly it will also be mandatory for the department to retain Dr. Jim Park's line as Director for Undergraduate Laboratories in case he should choose to retire. Taking care of our educational physics laboratories at both the lower and upper division is an important infrastructure task. The Director is usually also required to teach 1-2 classes each semester, like Modern Physics Lab.

The Electronics Laboratory has historically had 3 people, but has since the financial downturn in 2008 operated with only two people. The lab is currently short on advanced programing capabilities, so a new hire covering this area would strengthen the department substantially.

Apart from the concerns expressed above, the department currently has adequate staffing levels in the mechanical workshop, the business office, and the departmental office. However, the workload imposed on the staff is constantly changing, especially as many software packages as IRIS and BANNER places data entry and supervision at the departmental level, so we will always have to reserve to right to forward new requests for staffing, if the workload should be substantially increased.

## *Physics at the UT Space Institute (Submitted Spring 2012)*

The UT Knoxville Department of Physics and Astronomy has 3 tenured professors and 1 research professor at the University of Tennessee Space Institute (UTSI), which is located in Central Time Zone, in Tennessee's 4th congressional district, near Tullahoma, some 180 miles (3 hours) to the southwest of Knoxville. Although UTSI is fiscally independent of UT Knoxville, it is academically an integral part of UT Knoxville. This section explains how UTSI and its relationship to UT Knoxville and the UT System have changed in recent years; this is important to describe, because there is an opportunity to hire one or two new Physics faculty to be located at UTSI in the years ahead. This section also explains the past activities and future plans of the members of the UTK Department of Physics and Astronomy who are located at UTSI, as this is also an important factor in strategic planning for new hires.

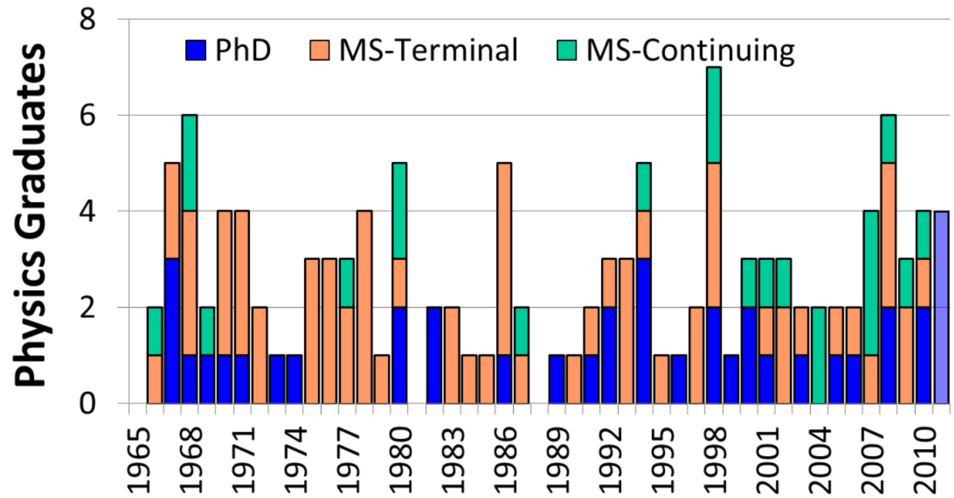
Prior to January 1, 2010, UTSI was a separate academic unit of UT Knoxville; its top administrator had the title of Vice President and reported to the UT Executive Vice President at the UT System level; UTSI was charged with developing its own bylaws and strategic plan, and hence physics faculty at UTSI were not included in previous UTK Physics Department strategic plans. Since January 1, 2010, UTSI's top administrator no longer holds the title of Vice President; Dr. Buddy Moore was appointed as Executive Director; he reports to the UT Knoxville Chancellor for most functions, but he still maintains a reporting line to the UT Executive Vice President at the UT System level for some functions (such as those associated with the Arnold Engineering Development Complex (AEDC) Air Force base).[1] He also interacts with Deans and Heads of Departments of the faculty members located at UTSI. These are: the Dean of the College of Arts and Sciences; the Head of the Department of Physics and Astronomy; the Dean of the College of Engineering; the Head of the Mechanical Aerospace Biomedical Engineering (MABE) Department; the Head of the Materials Science Department; the Head of the Industrial and Information Engineering Department; and the Head of the Department of Electrical Engineering and Computer Science. UTK faculty at UTSI hold positions and tenure in the corresponding UTK departments and their annual performance reviews are now conducted by the UTK department heads.

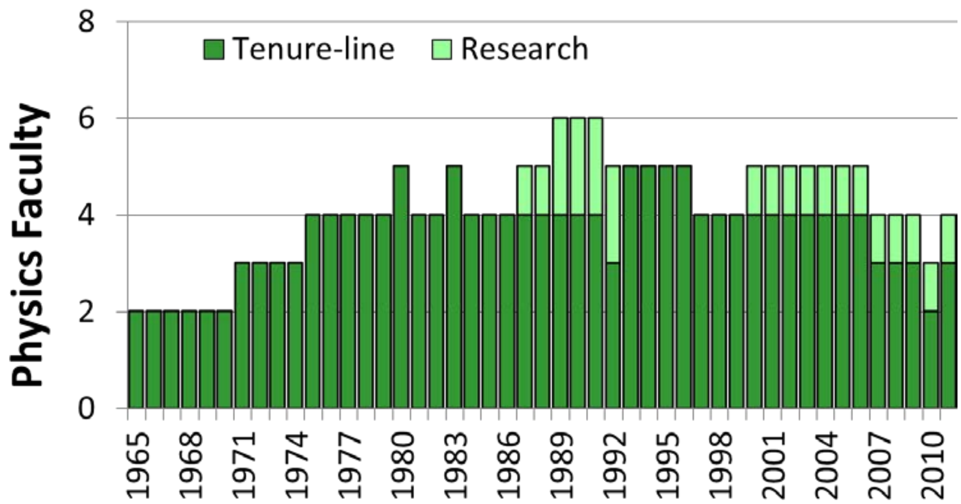
UTSI was established in 1964-5 to provide research and graduate-level education for AEDC; it is situated on land that belongs to the US Air Force. UTSI receives a separate line-item budget (presently ~$8M) from the State. If UTSI were closed, the tenured faculty located at UTSI would need to be absorbed by UTK, but UTSI's budget would not automatically revert to UTK or the UT System. UTSI is fiscally sound, but it has recently decreased in size due to retirements and it is currently rebuilding its faculty (presently 23 faculty, including 9 tenured). So far this year (AY 2011-2012), there has been one new faculty hire (non-tenure-line) in Engineering Management (Industrial and Information Engineering Department) and there are ongoing searches for 4 new tenure-line faculty members in the MABE Department. (The searches are managed by the UTK Department.) The possibility for a new faculty hire in Physics at UTSI, with search to begin in Fall 2012, has the support of the Executive Director of UTSI (who controls UTSI's budget), and

[1] http://president.tennessee.edu/docs/SystemOrgChart.pdf

would need the support of the UTK Department of Physics and Astronomy, and of the Dean of the College of Arts and Sciences. Note that although the salary and start-up funds for the position would come from UTSI, and so would not impinge on the budget of UT Knoxville (or the College of Arts and Sciences), the Department and the College would have the responsibility for providing an academic home to a new hire and for ensuring continuing quality in their academic program at UTSI.

Physics at UTSI has been, and continues to be, an important component of the interdisciplinary nature of UTSI. UTSI's first 2 new faculty hires (1965) and first 3 PhD degrees (1967) were in physics. The numbers of UT Knoxville Physics Graduates and Faculty at UTSI are shown in the two figures below.




Recent changes in physics faculty at UTSI include: the retirements of Profs. Mason (1996), and Lewis (2006); the hire of Research Assistant Professor Chen (2000); the sabbatical of Prof. Davis (AY 2010-2011). In the near future, we anticipate the retirement of Prof. Crater (planned for the end of AY 2014-2015), and we propose the hire of two new tenure-line faculty, one at the start of AY 2013-2014, with search to begin in Fall 2012 (supported by UTSI's Executive Director), and one at the start of AY 2014-2015 (depending on the budget situation and pending the approval of UTSI's Executive Director).

At the present time, there are 3 tenured physics faculty members and one research faculty member at UTSI. The fields of research expertise and core physics courses taught in recent years are listed in the table below:

| Faculty | Horace Crater | Lloyd Davis | Christian Parigger | Ying-Ling Chen |
|---|---|---|---|---|
| Position | Professor | B.H. Goethert Professor | Associate Professor | Research Assistant Professor |
| Start | 1975 | 1987 | 1989 | 1999 |
| Field | Theoretical / Particle | Optical / Molecular Bio / Nano /Chemical | Optical / Molecular / Atomic | Optical / Biomedical |
| Specialties include | Relativistic Quantum Mech., Dirac Eqn. | Single-molecule, Ultrafast/Femtosec. | Laser-induced breakdown spectros. | Eye (NIH) |
| Direct doctoral | Approved | Approved | Approved | |
| Core Phys. Courses | 511,512,521,522,531541,561,611,626,627 | 506,507,508,521,522 531,594,606,610,642 | 521,522,531,541,551555,571,572,573,601605,642,643 | |
| ISI Pubs. | 62 | 35 | 31 | 9 |
| Citations | 946 | 1045 | 321 | 168 |
| H-index | 17 | 12 | 12 | 5 |
| Service currently includes | President of UTSI Faculty Assembly | UTK Faculty Senate, President Elect of UTSI Faculty Assembly | UTK Graduate Council, UTK Faculty Senate Alternate | |

Prof. Crater conducts theoretical research primarily on the two and three body problems in relativistic quantum mechanics and quantum field theory, with applications in nuclear and particle physics. We anticipate that research in these areas will not continue at UTSI after he retires; hence the rest of this report will focus on Optical Physics and related areas, where new hires are proposed. Professors Davis, Parigger, and Chen conduct research in these areas and are members of the Center for Laser Applications (CLA). To further strengthen these efforts and rebuild critical mass, we propose that two new physics faculty hires at UTSI should also be in the general area of Optical Physics/Laser Applications, broadly defined, should be members of the CLA, and should also contribute to teaching graduate level courses in physics. We first address teaching and then discuss research in Optical Physics below.

The tenured physics faculty members at UTSI (Crater, Davis, Parigger) have taught all of the core graduate physics courses to students at UTSI with the exception of Phys. 513 and 514, Problems in Theoretical Physics, which is taught by Prof. M. Breinig at Knoxville using distance education connections to UTSI, and which is generally taken by first year graduate students in physics to help them prepare for the PhD qualifier examinations. One of us at UTSI generally serves on the UT Knoxville PhD qualifier examination committee each year. Many of the physics courses taught at UTSI are taken also by engineering students. Prof. Parigger is approved by the UTK Department of Mathematics to teach Math 571-572, Numerical Mathematics I-II, and Math 578, Numerical Solutions to Partial Differential Equations, and these are also taken by many engineering students. Dr. Crater has also been recently approved to teach Math 511-512, Applied Mathematics, by the UTK Department of Mathematics. These courses serve an important need as UTSI no longer has regular faculty members in the Department of Mathematics. Also, some have been required for the Interdisciplinary Graduate Minor in Computational Science, which has been completed by 2 recent physics doctoral graduates from UTSI (Robinson and Labello).

Physics faculty members at UTSI teach a number of 600-level courses that have also been taken by students at Knoxville by distance education, including Phys. 643 (Computational Physics), Phys. 605 (Laser Spectroscopy), Phys. 606 (Nonlinear Optics), and Phys. 610 (Quantum Optics). We anticipate that much of this need will continue or increase, and graduate teaching contributions from new physics faculty at UTSI will be needed. We would welcome faculty at Knoxville offering graduate-level classes to students at UTSI; shared teaching in emerging areas such as Biophysics could also be beneficial.

To help balance the course needs of students and the teaching load of the faculty at UTSI, careful planning is needed. As part of this planning, we try to select the intake of new graduate students so that certain courses are offered once every few years. UTSI does not hire Teaching Assistants (TAs); most graduate students have been supported on externally funded Research Assistantships, or in some cases Fellowships (e.g., NASA Space Fellowship); some students hold full-time jobs at AEDC. In order to help incoming students rapidly become useful in the laser laboratories to help with ongoing research, courses with a hands-on component, such as Phys. 506 (Experimental Methods), Phys. 507 (Contemporary Optics), or Phys. 508 (Laser Physics), are taken together with the core physics courses. Also, the courses Phys. 594 Special Problems, and Phys. 599 a—e Physics Seminars, are used to fill the need for teaching specialized topics, such as single-molecule spectroscopy, nano-optics, ultrafast laser techniques, etc.

The Center for Laser Applications is a resource for interdisciplinary research at UTSI. The CLA was established at UTSI in 1984 as one of the original Tennessee Higher Education Commission (THEC) Centers of Excellence, and was named one of the original Accomplished Centers in 1989. Its mission is to provide a multidisciplinary research center environment for the training of masters and doctoral graduate students in specialized science and engineering topics through participation in internationally recognized research. At present, the CLA has the following faculty: 2 Tenured in Physics (Davis and Parigger), 1 Research Assistant Professor in Physics (Chen), 2 Tenure Track Associate Professors in MABE (Moeller, Engineering Science, and Johnson, Materials Physics), 1 Research Professor in MABE (Murray, Chemistry), 1 Research Assistant Professor in Materials Science (Costa), and 1 Research Professor in Materials Science, who serves as CLA Director (Hofmeister). The annual budget from THEC is ~$880K; total restricted account expenditures in FY 2010 were $2,362,445.[2] The CLA has a wide array of lasers and diagnostics, a class 1000 clean room for microfabrication, a laser nanofabrication lab, a single-molecule lab, chemistry labs, cryogenic space vacuum chamber lab, X-ray, SEM,

[2] p. 72 of http://cla.utsi.edu/AnnualReport/CLA_Annual_Report_2010.pdf; the FY 2010 R-account expenditures per tenure-line faculty member (for comparison with the benchmarking section of the Physics Department Strategic Plan) works out to be ~$588K, well above the Peer Average.

microscope, and materials labs, a Mossbauer lab, as well as nanosecond, picosecond, and femtosecond laser labs.

Within the last 5 years, external funding for the Optical Physics / Laser Applications research conducted by Davis, Parigger, and Chen has been provided by the NIH, NSF, DARPA, and DOE (Sandia National Lab). Also, we and our students have engaged in four User Agreements for research conducted at the Center for Nanophase Material Science at ORNL (CNMS2006-059, CNMS2010-074, CNMS2011-250, CNMS2012-039). We anticipate that these activities, which involve fabrication and characterization of nanoscale devices for single-molecule spectroscopy and energy applications, will continue in the years ahead. During AY 2010-2011, Davis also received funding from NIST as a Visiting Fellow to JILA, CU Boulder.[3] He continues to collaborate with JILA on a recent patent application and publications on a unique flow cytometer, which is now in use for studies on directed evolution of genetically engineered proteins.
Davis is a participating faculty member of the UTK Center in Chemical Physics;[4] in the past, physics students at UTSI have participated in the annual UTK Chemical Physics symposium; he is also an External Associate of the Vanderbilt Institute for Integrative Biosystems Research and Education (VIIBRE) at Vanderbilt University;[5] CLA faculty and physics students occasionally use research facilities at Vanderbilt University and we attend the annual Vanderbilt "Nanoday" symposium of the Vanderbilt Institute of Nanoscience and Engineering (VINSE).[6] We participate in the NSF TN-SCORE program (which is led by UT Executive Vice President David Milhorn) through research collaboration with Prof. Sandy Rosenthal (Fellow of AAAS) at Vanderbilt University in the area of THRUST 3—Nanostructures for Enhancing Energy Efficiency.[7] In this work, we have built a custom microscope for single-molecule spectroscopy and used it to study white-light emission from single ultrasmall quantum dots, which is of interest for energy conversion applications. Our ongoing work is using photon anti-bunching (a quantum mechanical property of light from single emitters) to study energy transport physics in quantum dots. Two of our doctoral students are currently engaged in related research to track and trap single nanoscopic emitters, such as a single protein molecule, to enable extended observations as it diffuses freely in solution in 3 dimensions without confinement. This has not been achieved before and would enable new studies of protein folding and biomolecular interactions of interest to the NIH.

We have previously fabricated nanochannels for 1-dimensional single-molecule trapping at the CNMS; this work was part of a DARPA funded project ("SPARTAN: Single Protein Actuation by Real-time Transduction of Affinity in Nanochannels") in which we included contributions from faculty members from the UTK College of Engineering and a staff member at ORNL. We have recently developed a new method for using single pulses from an amplified femtosecond laser to fabricate very long nanofluidic channels; through an invention disclosure to UT Research Foundation, we have found an industrial partner in Missouri to further develop the technology;

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[3] Rated No. 1 in graduate programs in AMO Physics http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-science-schools/atomic-science-rankings
[4] http://www.chem.utk.edu/~cp/faculty.php
[5] http://www.vanderbilt.edu/viibre/people.html
[6] http://www.vanderbilt.edu/vinse/news_details.php?NewsID=198
[7] http://www.tnepscor.org/research/researchers.aspx

and with funding from the NIH, we have recently demonstrated parallelized single-molecule detection in an array of nanochannels, which should have future application to biosensors and pharmaceutical drug discovery (a topic which we have previously worked on with funding from Abbott Laboratories, Chicago, IL).

The CLA has developed a femtosecond laser facility that enables direct writing of microfluidic devices in fused silica or glass; we also have facilities for conventional photolithography; some of our custom devices are in use in collaborative cell biology experiments at Vanderbilt. The UT Knoxville Department of Physics and Astronomy recently hired Dr. Jaan Mannik as tenure-track Assistant Professor to work in the department's emerging area of Biophysics; Dr. Mannik's interests include using microfluidics and single-molecule imaging to study biophysical processes in *e-coli* cells; in Fall 2011, Davis visited Mannik at UTK and arranged travel support for him to visit UTSI and present a seminar on his work; we are continuing our discussions and hope to be of support to Dr. Mannik as he sets up experiments in the SERF building at UTK. We and Dr. Mannik also have overlapping interests with Prof. Ken Kihm,[8] UTK Department of MABE, and will continue discussions on potential future collaborations.

In using a femtosecond laser for direct-write fabrication, features smaller than the diffraction limit can be produced by virtue of the strong non-linearity of the physics. We are setting up an ultrafast pump-probe experiment to further elucidate physical processes that occur during femtosecond laser optical breakdown in transparent solid materials. This work is stimulated in part by papers that cite our earlier research on fabricating a very high aspect nanohole by engineered focusing of a single femtosecond laser pulse. We are also collaborating with Hofmeister and Costa in the CLA on using arrays of such high-aspect nanoholes as a high-surface area template for creating structures that could be used in making a prototype super-capacitor for energy storage applications; this is supported by a UT Research Foundation Maturation Fund Grant to Hofmeister and is in collaboration with an industrial partner.

Understanding the physical processes that occur during optical breakdown in gases has been a major topic of research for Parigger and his students and has considerable overlap with the work discussed above on femtosecond laser breakdown in transparent solids. Previous and ongoing research by Parigger and his students has included experimental, theoretical, and computational studies on the optical breakdown processes over disparate timescales, from femtoseconds to milliseconds, as well as detailed spectroscopic studies for diagnostic applications, especially for laser-induced plasmas in gases and multiphase environments. Applications include Laser-Induced Breakdown Spectroscopy (LIBS), which has capabilities for remote sensing, as well as combustion diagnostics. While atomic emission spectroscopy has been used successfully for various diagnostic applications, further theoretical developments and computational modeling are required for new analytical applications. Opportunities for external funding include the Plasma Physics division of the NSF, the DOE, Sandia National Lab, and support of the UTSI / AEDC collaboration. This area of research also meshes well with collaborative, multidisciplinary, graduate education at UTSI; for example, Phys. 643, Computational Physics, which has drawn participation of students from Engineering programs at UTSI and UTK, as well as Computer

[8] http://www.engr.utk.edu/mabe/fac-kdk.html

Science, Mathematics, and Physics programs. A paper that addresses these activities is scheduled to appear this spring in the peer-reviewed Journal "Computers in Science and Engineering."

Dr. Parigger's research collaborators in this area include Prof. E. Oks, Auburn University, on atomic species and the hydrogen Balmer series, which is accessible in the visible spectrum; Mr. J. Hornkohl on quantum mechanical calculations of diatomic spectra; Dr. Amy Bauer with Applied Research Associates and at Denver University, on Spark Induced Breakdown Spectroscopy (SIBS) and microwave assisted electrically-induced sparks for detection of trace atomic and molecular emission signatures; Dr. Dennis Alexander, University of Nebraska, Lincoln, on channelization in the interaction of amplified femtosecond laser radiation with materials and interactions involving lens-axicon combinations; Dr. Anna Keszler, Chemical Research Center of the Hungarian Academy of Sciences, and researchers at Sandia National Laboratories, Albuquerque NM, on related molecular applications of flame diagnostics. Dr. Parigger also actively participates in International Conferences on Spectroscopic Line Shapes (ICSLS) that are held bi-annually, alternating between Europe and USA. He attended ICSLS 2004 (Paris, France), ICSLS 2006 (Auburn University, USA), will attend ICSLS 2012 (St. Petersburg, Russia) and will organize and host the 2014 ICSLS conference (UT Space Institute, Tullahoma, USA). He is a member of the organizing committee, and is also a member of the editorial board of the peer-reviewed Journal "International Review of Atomic and Molecular Physics."[9]

Dr. Chen's research expertise also overlaps with the above described activities, including work she conducted earlier as a postdoctoral fellow at Sandia, Livermore. However, in recent years she has been occupied mostly on research in the area of biomedical optics. She is working on the development of a patented device for low-cost computerized eye examinations for children. Called the Dynamic Ocular Evaluation System (DOES), the device, which was developed by Drs. Chen, Shi (postdoctoral fellow), and Lewis (professor emeritus in physics), can test vision but can also potentially detect learning disabilities, such as dyslexia or neural disorders such as autism. This work is supported by two grants from the NIH as well as a UT Research Foundation Maturation Fund Grant; a clinical test at Tullahoma's Walmart Vision Center is currently underway. Several UTK Physics graduate students at UTSI have been involved in the research; Dr. Wang, of the Wang Vision Institute[10] in Nashville has served on doctoral committees.

The physics faculty members at UTSI anticipate continuing to serve the Land-Grant Mission of the University of Tennessee in that many of our students are from Tennessee, some are from surrounding counties, and most are US citizens. We also serve the mission of UTSI to provide research and graduate-level education for AEDC: In the 6-year period 2006-2011, 17 of the 21 graduate degrees in physics were awarded to US citizens; 7 of the 21 degrees were awarded to students affiliated with AEDC at some time during the course of their studies, and one other is now permanently employed by AEDC.

Many of the physics graduate students at UTSI have been involved in outreach activities. In Fall 2007, the physics students at UTSI established the UTSI Student Chapter of the Optical Society of America (OSA); this is still the only student chapter of OSA in Tennessee; they received a

[9] http://www.serialspublications.com/journals1.asp?jid=560&dtype=2&jtype=1
[10] http://www.wangvisioninstitute.com/

$1K start-up fund from OSA; they proposed and received a $1.5K grant for Outreach activities from OSA, which they have used to fund supplies and transportation for school visits; they also sponsored high school students and teachers to attend CLA's 2-week Computational Science programs last summer.[11] As these students graduate and leave UTSI we will support them in passing on these activities to new students.

UTK Physics Graduates at UTSI, 2006-2011
(The list of students is in order of their graduation dates (**End**).)

| Student | Degree | Begin<br>**End** | Advisor | Committee | *Dissertation Title*<br>Sources of Funding |
|---|---|---|---|---|---|
| Karen Norton* | MS | 05-04<br>**08-06** | Davis | Crater, Parigger | *Ultraviolet image analysis of spacecraft-exhaust plumes*<br>**AEDC**-sponsored GRA; now works at **AEDC** |
| David Ball | PhD | 08-02<br>**12-06** | Davis | Crater, Parigger, Chen, Lewis, Compton, Antar | *Single-molecule detection with active transport*<br>Abbott Labs, NSF, UTSI, CLA |
| Jesse Labello* | MS | 08-05<br>**12-07** | Crater | Parigger, Davis | *Characterization of the temperature dependence of optical components in the 10V cryo-vacuum chamber*<br>**AEDC**-sponsored GRA |
| Lei Shi | MS | 08-05<br>**05-08** | Chen | Lewis, Crater | *Non-thesis*<br>CLA |
| Matthew Duran* | MS | 06-04<br>**05-08** | Crater | Davis, Lewis | *Modeling the ground state baryon octet using a generalization of the Lagrange triangle*<br>UTSI; now works at **AEDC** |
| William Robinson | MS | 06-06<br>**08-08** | Davis | Crater, Whitehead | *Simulation of single-molecule trapping in a nanochannel*<br>NIH, DARPA, CLA |
| Howard Frederick* | MS | ?<br>**12-08** | Crater | Parigger, Davis | *Experimental Determination of Emissivity and Resistivity of Yttria Stabilized Zirconia at High Temperatures*<br>**AEDC**, part-time student, works at **AEDC** |
| Kevin Baker | PhD | 06-05<br>**05-09** | Lewis | Chen, Crater, Parigger, Kimble, Wang | *Novel Approach to Ocular Photoscreening*<br>NASA Space Fellowship |
| You Li | MS | 08-07<br>**08-09** | Davis | Crater, Parigger | *Single-molecule detection of near-infrared phthalocyanine dyes*<br>NIH |

[11] http://www.utsi.edu/ContEd/Outreach/2011Computational_Science_Workshop.pdf

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|---|---|---|---|---|---|
| Jason King | MS | 06-07<br>**08-09** | Davis | Parigger,<br>Hofmeister | *Microfluidic device for the electrokinetic manipulation of single molecules*<br>UTSI, DARPA, NIH |
| Justin<br>Crawford | MS | 08-07<br>**08-09** | Davis | Parigger,<br>Crater | *High-sensitivity spectral fluorescence lifetime imaging for resolving spectroscopically overlapping species*<br>NIH, CLA |
| Bo Tan | PhD | 06-05<br>**08-09** | Lewis | Chen, Crater,<br>Parigger,<br>Wang | *Optical Modeling of Schematic Eyes and the Ophthalmic Applications*<br>CLA |
| James<br>Germann | MS | 06-07<br>**05-10** | Davis | Davis,<br>Parigger,<br>Crater | *Three dimensional localization with time-gated photon counting and maximum-likelihood analysis*<br>CLA, DARPA, NIH |
| William<br>Overcast* | MS | 08-06<br>**05-10** | Crater | Parigger,<br>McGregor | *Digital Aperture Photometry Utilizing Growth Curves*<br>**AEDC**, part-time student, works at **AEDC** |
| Jesse Ogle* | MS | 08-07<br>**08-10** | Parigger | Crater,<br>Moeller | *Non-thesis*<br>**AEDC**-sponsored GRA |
| William<br>Robinsonǂ | PhD | 08-08<br>**08-11** | Davis | Parigger,<br>Crater,<br>Breinig, Smith | *Monte Carlo Simulations of Single-Molecule Fluorescence Detection Experiments*<br>NIH, CLA, Mason Fellowship |
| Lei Shi | PhD | 06-08<br>**08-11** | Lewis | Chen, Crater,<br>Parigger,<br>Wang | *Quantitative Binocular Assessment Using Infrared Video Photoscreening*<br>CLA, NIH |
| Alexander<br>Woods | MS | 08-10<br>**08-11** | Parigger | Crater,<br>Moeller | *Non-thesis*<br>TA in Knoxville until June 2011, CLA |
| William<br>Ring* | MS | 08-10<br>**08-11** | Parigger | Crater,<br>Moeller | *Non-thesis*<br>TA in Knoxville until June 2010, CLA, AEDC |
| Jesse<br>Labello* ǂ | PhD | 01-08<br>**12-11** | Parigger | Crater,<br>Manella,<br>Davis, Moeller | *Water Ice Films in Cryogenic Vacuum Chambers*<br>**AEDC**-sponsored GRA; now works at **AEDC** |
| Joshua<br>Whitney | PhD | 08-06<br>**12-11** | Crater | Parigger,<br>Davis,<br>Steinhoff | *Baryon Spectrum Analysis using Dirac's Covariant Constraint Dynamics*<br>TA in Knoxville until 2006, UTSI |

*Graduates affiliated with AEDC during their studies or now working at AEDC.
ǂRecipient of PhD in Physics with Interdisciplinary Graduate Minor in Computational Science (IGMS).