FIU

FLORIDA INTERNATIONAL UNIVERSITY

College of Arts & Sciences

Department of Physics

2007 Self Study

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1 Executive Summary

The Department of Physics strives to maintain excellence in both research and education. In its research activities, it maintains one of the most vibrant and successful programs at the university. All members are active in research, and the department as a whole is one of the leading research departments at FIU, as measured by annual publications (an average of 3 articles in peer reviewed journals per faculty per year), external grant funding (an average of 140,000 dollars per faculty per year), and substantiated by the department's ranking in the Academic Analytics, LLC, survey (§2.6). Over the past several years, the department has strengthened existing research groups, and through participation in the CHEPREO project (p. 3), has expanded into new research areas. The nuclear physics group has continued to grow and has achieved both national and international prominence (§5.1.2). Condensed matter physics is showing promising strength in several research fields, especially in the area of correlated electron materials, nanomaterials and their applications (§5.1.2). Two faculty members of this group have received a prestigious National Science Foundation CAREER award. The department is active in experimental and observational programs at a number of national and international facilities, including the Thomas Jefferson National Accelerator Facility (Jefferson Lab, §4.1.3), Oak Ridge National Laboratory (§5.1.2), CERN (§4.1.3), and the SARA astronomical observatory in Arizona, with a member of the department currently serving as observatory director (§5.1.2).

Since the previous program review, the department has improved and expanded its educational programs, both at the university and the community at large. The department now offers two baccalaureate degrees – the original Bachelor of Science degree and the newer Bachelor of Arts degree, which has been designed to accommodate the needs and interests of a wide range of students. The physics undergraduate and graduate curriculum has been revised and updated in 2005. Due in part to recruitment efforts and to programs connected with the CHEPREO project, the number of upper division students seeking undergraduate degrees in physics has increased at an average rate of 4.6% per year and compares favorably to the average annual growth of 3.5% of all FIU undergraduate programs combined. At the graduate level, the department offers both the Master of Science and the Doctor of Philosophy degrees and has been successful in attracting an increasing number of graduate students and providing them the research and educational environment necessary for degree completion. Graduate FTEs in Physics have risen an average of 6.5% per year since 2001. Lower division courses, which generate 90% of the total Physics FTE production, have increased at an average annual rate of 6.6%. Through the CHEPREO project, the department has established a recruitment and educational outreach program with local high school teachers. Other community outreach efforts have included a popular public lecture series, regular public sky viewing events using department telescopes, and department open houses designed to introduce local high school students to the educational opportunities the department has to offer.

Despite the department's success in research, education and outreach, a number of issues remain that adversely affect the department and hinder the full realization of its potential. Perhaps the most serious is the lack of net growth in the number of faculty. While the department has added several new faculty members since the last review, it has also lost a number of faculty due to retirements, moves to other institutions, and, in one case, the assumption of an administrative position. Large increases in physics FTEs both at the upper and lower division, combined with a nearly constant number of faculty, have resulted in a significant increase in student-to-faculty ratio, from a pre-2001 value of 14 to the current value of over 20. A second problem associated with the lack of department growth is the small size of several research groups, which suffer several disadvantages in competition with larger groups – quality graduate students are harder to attract and retain because of limited opportunities to interact with experts in their chosen area of research, professional contacts between colleagues working in the same field are less frequent, and grants may be more difficult to obtain since many funding programs target large research groups or centers.

Other issues which adversely impact the department, affecting faculty morale and reducing the effectiveness of the department, include low faculty salaries, inadequate graduate student support, laboratory space issues, and poor administrative support. Low faculty salaries and related issues such as limited start-up funds and restricted research laboratory space affect the department by making it more difficult to attract and retain quality faculty. While the number of college-funded graduate assistantships has increased significantly since the last program review (from 13 in 2001-02 to 17 in 2006-07), it is still well below the level typical for most Very High Research Activity universities (the level FIU aspires to achieve). Limited graduate student support restricts the number of graduate students the department can accept, particularly doctoral students, which directly impacts the level of research that can be conducted. Scarce laboratory space impacts both the research and educational activities of the department. For example, limited space currently available for educational physics labs caps the number of students that can be accepted each semester in lower division laboratory courses, thereby also limiting the number of students that can be accommodated in lower division lecture courses which produce the bulk of the department's FTEs. Finally, difficulties related to the administration of external grant budgets during the transition to a new online accounting system have diverted faculty from more productive uses of their time.

Issues raised in this summary are addressed in the following sections. We present the successes and achievements of the department since the last program review and outline some of the steps that will be necessary to elevate the department to one of the top ranked physics departments in the nation.

This document was prepared by Oren Maxwell, Professor of Physics, and Walter Van Hamme, Professor of Physics and Department Chair. Faculty representing the various research groups contributed group-specific material.

2 Recommendations of the 2001 Program Review and Responses

In this section we list in italic specific recommendations made in the 2001 program review. Actions taken follow each of the quoted recommendations.

2.1 Faculty Positions

> *Replace the three faculty (1 in condensed matter/nanophysics, 1 in theoretical nuclear physics, and 1 in experimental nuclear physics) who left the department to accept positions elsewhere. Add 1 or 2 new faculty in nanophysics or biophysics. Attempt to coordinate at least one of these positions with the condensed matter replacement position and possibly with the Spallation Neutron Source (SNS) group at Oak Ridge National Laboratory. In the longer term and with FIU enrollment growth, add several more faculty in nano/biophysics, optical physics/quantum computing, nuclear/particle astrophysics, and cosmology/particle theory.*

The department has only been partially successful in replacing departed faculty and in acquiring new positions. In nuclear physics, the departed theorist was replaced in 2002, but not the experimentalist. The nuclear experimental group is still one member short of the number specified in the MOU between FIU and the Thomas Jefferson National Accelerator Facility (TJNAF). One faculty member in the nuclear theory group moved to a university administrator position in 2004. In the solid state/condensed matter group, the departed solid state surface physicist was replaced in 2003, but no new positions in nanophysics have been added. The biophysics group has increased in size to three members with the addition of one new faculty member in 2006. Under the impetus of the Center for High Energy Physics Research & Education Outreach (CHEPREO)[1] grant, a new area of research in Physics Education (PER) has been established, and one PER faculty member was added in 2005. The Atomic/Molecular/Optics (AMO) group lost two members due to retirement and has decreased in size from three to one since 2001. Finally, in order to fulfill another CHEPREO grant obligation, the department added a visiting assistant professor in a non-tenure earning line in the Fall of 2007. This person is an experimental elementary particle physicist (EPP) working on the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) facility at the Conseil Européen pour la Recherche Nucléaire (CERN). Table 1 (§3.2, p. 6) lists the number of tenured or tenure-earning physics faculty[2] since 2001. Overall, the size of the department has remained essentially constant, despite significant increases in both the size of the university (in the period 2001-07, FIU has experienced an average percentage FTE growth of 3.9% per year) and the number of students in the department (in the same period, the average percentage Physics FTE growth was 6.5% per year).

2.2 Graduate Students

> *Increase the number of graduate students supported by Teaching Assistantships or Research Assistantships to 40. Address the out-of-state graduate tuition issue to provide improved cost-sharing among the university, the state, and external grants.*

Since 2001, the number of E&G funded Graduate Assistantships (GA) allocated to the department has increased at a steady rate, from 13 in the Fall of 2001 to 18 in the Fall of 2007. The number of C&G supported Research Assistantships (RA) has jumped from a number of 7 to 8 before 2004 to a post-2004 number between 10 and 12. Both these increases have resulted in a modest rise in graduate student enrollment, as shown in Table 1 and discussed in §3.2 on p. 6 of this review. The current (Fall, 2007) number of 30 sponsored graduate students (18 GAs and 12 RAs) is well below that recommended in the 2001 program review.

2.3 Staff Positions

> *Restore the frozen machinist position and possibly add a computer support staff position.*

Staff positions have been added since the last program review, but not to the extent recommended in the review. Currently, the department has two full-time machinists, one electronics shop specialist, one computer specialist, one physics and one astronomy lab manager, for a total of six technical

[1]See http://www.chepreo.org/ for a complete list of partner institutions and an overview of the center's activities.

[2]This number includes faculty on loan to the university administration. Therefore, it may be higher than the effective number of faculty used in other parts of this document.

staff, compared with five in 2001. The number of non-technical office assistants remains at three, the same number as in 2001.

2.4 Space Issues

> *Address the astronomy lab/observatory issue. Provide office or work space for all graduate students and post-doctoral fellows.*

Space issues addressed in the previous program review have been mitigated to some extent. Currently, all experimental physicists have at least minimal lab space. A room in the PC building for the indoor astronomy labs was allocated as a temporary fix. The current observing pad designated for the outdoor astronomy labs has been compromised by new construction and lighting. Recent successful contacts with an outside donor to fund construction of an astronomy tower are expected to resolve the astronomy lab/observatory space. The relocation of two research labs to the OE building and the internal reallocation of physics space has freed up space for graduate students, post-doctoral and visiting fellows. As in most physics departments, office space for graduate students remains scarce.

2.5 Introductory Courses

> *Change introductory courses to a large lecture room format in order to improve instruction and reduce faculty teaching assignments. Develop a tutorial program.*

Attempts to increase the size of introductory physics sections have met with limited success because of the lack of large classrooms at FIU. A tutorial program has been developed under the auspices of the Title V grant, but this has mainly been oriented toward physics majors, rather than the non-majors that constitute the bulk of the students taught in introductory courses.

2.6 Departmental Ranking

> *Seek a ranking within the top 75 to 100 physics departments and seek to have several faculty become fellows of the American Physical Society.*

FIU has contracted with Academic Analytics, LLC, to produce a Faculty Scholarly Productivity (FSP) Index for departments that have doctoral programs. The index is a tool to assist in the evaluation of doctoral programs and to show the level of scholarly output such as journal articles, citations of journal articles, grants and awards. For the academic year 2004-05, the department was ranked in the fourth decile mean, 0.34 standard deviations above the mean of benchmark physics departments.[3] For AY 2005–06, the department scored 0.64 standard deviations above the mean and moved up into the third decile mean. Within FIU, Physics was the top ranked science department in each of the two academic years.

No faculty have yet become fellows of the American Physical Society.

[3] Benchmark institutions for Physics are Arizona State University, Michigan State University, Pennsylvania State University, SUNY at Stony Brook, North Carolina State University, The University of Texas at Austin, The College of William and Mary, New Mexico State University, Hampton University and Florida State University.

3 Program Description

3.1 Degrees Offered

The Department of Physics currently offers two baccalaureate degrees, a Bachelor of Science and a Bachelor of Arts in Physics, and two graduate degrees, a Master of Science and a Doctor of Philosophy in Physics. The department also offers minors in Physics and Astronomy.

The **Bachelor of Science** (BS) degree is primarily intended for students who wish to pursue a career in physics or a related discipline within an industrial, governmental, or academic setting. The B.S. degree prepares students who wish to pursue high school teaching careers. The degree provides an excellent background for students seeking an advanced degree before entering the job market. The B.S. degree requires 60 credits of lower division preparation followed by 60 credits of upper division courses in physics and mathematics.

The **Bachelor of Arts** (BA) degree is intended for students who wish to pursue a career outside of physics which either requires or would benefit from a strong background in physics. The B.A. program allows students to pursue parallel studies in other disciplines or preprofessional certificate programs. The B.A. degree requires the same lower division preparation as the B.S. degree but tracks offer a more flexible curriculum at the upper division level.

The **Minor in Physics** is primarily intended for students who wish to acquire a background in physics beyond the introductory level, but who do not intend to pursue physics as a career. It requires completion of the calculus based introductory physics sequence with labs, the modern physics sequence with labs, and one additional upper division course.

The **Minor is Astronomy** is intended for students who wish to acquire a background in astronomy beyond a survey course level. It shares requirements with the Minor in Physics and includes additional courses in introductory and observational astronomy.

The **Master of Science** (MS) degree is intended to provide advanced training for students who plan to pursue a career in physics that is not primarily research oriented. The M.S. degree requires 45 credits of graduate work and a master's thesis that describes original research conducted under the supervision of a Physics Department faculty member. It is generally expected that students will complete the requirements for the M.S. degree within two years of admission to the program. The M.S. in Physics has been offered at FIU since 1987.

The **Doctor of Philosophy** (PhD) degree is primarily intended for students who wish to pursue a research-oriented career in physics in an industrial, governmental, or academic setting. To acquire doctoral student status, students must pass a written comprehensive exam and present an oral summary of their intended doctoral research. The PhD degree requires 90 credits of graduate work and a doctoral dissertation that describes original research conducted under the supervision of a faculty member with graduate dissertation adviser status. Before graduating, the physics doctoral student will have acquired teaching experience, experience in presenting original work at professional conferences, and will have participated in the preparation of manuscripts for publication in peer-reviewed professional journals. The Ph. D. in Physics has been offered at FIU since 1999.

3.2 Undergraduate and Graduate Students

Table 1 lists the number of undergraduate majors, undergraduate minors, and graduate students in the department by year since the last program review. In each case the numbers given are for the Fall semester of the year indicated. For comparison, the total number of students and total number of FTEs at FIU are also listed. Note that the FTE numbers are given for the full academic year beginning with the Fall semester of the year indicated. As this table reveals, the number of

Table 1: Number of Physics Faculty and Students, and FIU Totals

	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Faculty	20	21	22	21	21	22
Undergraduate Majors	35	31	36	45	45	60
Graduate M.S.	14	9	9	10	22	9
Graduate Ph. D.	10	17	18	25	13	23
Graduate Total	24	26	27	35	35	32
E&G-funded TAs	13	15	15	18	17	17
C&G-funded RAs	8	7	7	13	12	10
Total Students	32686	33885	33864	35061	37424	38537
Total FTE Students	20016	20776	21052	21808	23269	24279

undergraduate physics majors has increased more rapidly (at an average percentage increase of 12.5% per year) than the overall university enrollment (average percentage increase of 3.4% per year). The increase in number of physics majors can be attributed in part to recruitment efforts by the department, including new programs that target both high school students and undergraduates who are either undecided as to major or considering changing majors.

High school students are targeted through open houses and similar activities, and through contacts with high school physics teachers. Instrumental in this regard is the CHEPREO project which includes a significant education and outreach component and has created a community of affiliated teachers who participate in CHEPREO-sponsored summer education workshops and follow-up activities during the school year. These teachers encourage their students to seek out science careers; many of these students later attend FIU. An informal survey taken a year ago revealed that nearly 50% of our undergraduate majors came from local high schools having one or more teachers that attended CHEPREO modeling workshops, indicating that potentially half of our majors have been influenced in their choice of college and program by teachers who participated in CHEPREO-sponsored activities. The CHEPREO project also supports several sections of studio-based introductory courses, fellowships for physics majors, and a physics learning center (PLC), all of which have attracted a number of students. Located in the VH building, the PLC offers an attractive space for students to hang out, interact with each other, study, do homework, prepare for class and be part of a community of learners.

The recent expansion of the undergraduate program to include a B.A. degree has also enhanced recruitment efforts by enabling the department to offer a variety of undergraduate programs serving different needs, including preparation for graduate, medical or business school.

Graduate student enrollment has increased somewhat more rapidly than total university enrollment, but not as rapidly as recommended in the previous program review. In the discipline of physics, graduate student enrollment is determined mainly by the number of available graduate assistantships. We have seen an increase in the number of E&G funded TA lines (from 13 in the Fall of 2001, to 18 in the Fall of 2007), but university graduate student support continues to be below the levels necessary to achieve the goals recommended in the previous program review. There has been a modest increase in the number of C&G supported RA lines, from 7 to 8 lines at the beginning of the review period to a current number that fluctuates between 10 and 12 RA lines.

3.3 University Core Curriculum Courses

The Physics Department offers a number of courses which fulfill the physical sciences requirement of the university core curriculum. These include

- AST 2003/AST 2003L Solar System Astronomy and Lab
- AST 2004/AST 2004L Stellar Astronomy and Lab
- PHY 1020/PHY 1020L Understanding the Physical World and Lab
- PHY 2048/PHY2048L Physics with Calculus I and Lab
- PHY 2049/PHY2049L Physics with Calculus II and Lab
- PHY 2053/PHY2053L Physics without Calculus I and Lab
- PHY 2054/PHY2054L Physics without Calculus II and Lab

AST 2003, AST 2004, and PHY 1020 are survey courses intended primarily for students whose major is not in a scientific or technical discipline. These courses are designed to introduce students to fundamental concepts and ideas in astronomy and physics without the use of sophisticated mathematics.

The PHY 2048-49 sequence is the standard, calculus-based introductory physics sequence directed primarily toward science and engineering students who expect to make extensive use of physics concepts and principles in their future careers. Many premedical students also take this sequence instead of the less rigorous PHY 2053-54. Students who successfully complete the PHY 2048-49 sequence will have acquired the strong background in introductory physics necessary to complete more advanced courses in their disciplines.

The PHY 2053-54 sequence is an algebra-based physics sequence that is less rigorous than the PHY 2048-49 sequence. It is intended primarily for students who need a thorough background in introductory physics, but who do not expect to make extensive use of physics concepts and principles in their future careers. Many of the students who take this sequence intend to pursue careers in one of the medical professions.

3.4 Student to Faculty Ratios

During the period of this program review, student FTE production by the department has increased significantly, as indicated by the data presented in Table 2. This table lists student annual FTE (AFTE) broken down by category (lower and upper division and graduate), total AFTE, and the number of "effective" FTE faculty, i.e. excluding one faculty member on loan to the university administration. Since 2001 the department has increased its total student AFTE at a rate of 24 ± 3 (mean error) units per year. To a large extent, this increase has been due to rapid enrollment

Table 2: FIU Physics Faculty and Student FTE Evolution

	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
FTE Faculty[a]	20	21	21.5	20	20	21
Lower Division	284	316	335	342	398	387
Upper Division	9	9	10	12	12	11
Graduate	18	17	20	22	21	24
Total AFTE	311	342	365	376	428	423
S/F Ratio	15.6	16.3	16.9	18.8	21.4	20.1
FIU Total AFTE	20017	20776	21052	21808	23269	24279

[a]For 2004-07, excluding faculty on loan to the University Administration.

growth in lower division service courses, as reflected in the 22 ± 3 FTE increase per year in the lower division. Upper division FTEs have increased at the more modest rate of 0.6 ± 0.2 units per year, while graduate FTEs have increased at a rate of 1.3 ± 0.3 FTEs per year. Because the number of FTE faculty has not increased since 2001, student-to-faculty FTE ratios have increased dramatically. In the decade preceding 2001, AFTE Student to Faculty ratios were essentially flat, fluctuating around an average value of 14.2. Since 2001, this ratio has increased steadily at a rate of 1.14 ± 0.23 per year and now has a value of 20, 40% above the pre-2001 average. This point is discussed further in §7.1 on p. 19, where we argue in favor of increasing the number of tenure-earning faculty lines allocated to Physics.

3.5 Continuing Education of Physics Graduates

Table 3 shows the number of students graduated with one of the degrees offered by the department. The table also includes information on the number of graduates continuing their education or finding employment. As the table indicates, FIU physics graduates are generally successful at either finding

Table 3: FIU Physics Degree Production and Post-degree Outcomes

Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
BS	4	7	1	11	3	10
BA	...	...	...	3	0	2
BS/BA → Graduate	4	2	1	10	3	9
BS/BA → Teacher	0	2	0	0	0	1
BS/BA → Other	0	3	0	1	0	2
PHY Minor	0	0	0	0	0	2
MS	1	3	3	1	1	3
MS → Ph. D.	0	2	3	0	0	2
MS → Other	1	1	0	1	1	1
PhD	...	...	1	6	1	2
PhD → Postdoc	...	...	1	2	0	1
PhD → Academic	...	...	0	3	1	0
Phd → Other	...	...	0	1	0	1

employment in a physics-related profession or at gaining admittance to a higher degree program.

4 Major Program Changes

In this section we address some of the program changes that have emerged since the 2001 review and are expected to significantly shape the program in the next decade.

4.1 Changes in the Discipline – New Themes

4.1.1 Biophysics and the Medical School

Molecular biophysics is an area that has seen explosive growth over the past decade and offers exciting prospects for technological and biomedical innovation. The field is at the center of intense international competition. Currently, the department has a theoretical group working on protein folding and protein aggregation. In addition to the fundamental physics of these processes, the research has direct biomedical applications for prion related diseases and many others. Expanding this group in the experimental area will enable strong synergistic activities between the group and the medical school.

4.1.2 Nanophysics and its Applications

One of the most rapidly developing fields in physics today is nanophysics, which concerns the physical properties of objects on the scale of one billionth of a meter. At this scale, the behavior of materials differs fundamentally from their bulk behavior and is governed by the rules of quantum mechanics. Nanomaterials possess properties that lead to innovative applications in materials science, energy generation, nanoelectronics and biomedicine. FIU has already established a strong nanomaterial research program with interdisciplinary expertise and state-of-the-art research facilities. Expansion of this effort represents an excellent opportunity to establish a major presence in an exciting new field.

4.1.3 New Facilities in Nuclear and Particle Physics

Within the realm of nuclear and particle physics, a major upgrade has been planned for the Continuous Electron Beam Accelerator Facility (CEBAF) operated by the U.S. Department of Energy at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, Virginia. By increasing the CEBAF beam energy from 6 GeV to 12 GeV, new research areas will be opened up that have not been previously accessible at the laboratory. In particular, with the higher energy, it will be possible to make more precise and more efficient measurements at high momentum transfers, to carry out more detailed studies of the structure of nuclei and elementary particles, and to conduct searches for new types of so-called “exotic” particles. The members of the nuclear physics group are actively involved in both the design and construction of new equipment for the upgraded machine and in the design of new experiments to be carried out at the higher beam energy.

Another important development in particle physics is the advent of the Large Hadron Collider (LHC) at the European Center for Nuclear Research (CERN). This 14-TeV machine, the largest accelerator in the world and scheduled to begin running experiments in July of 2008, will create new opportunities in particle and nuclear physics. FIU is a member of the Compact Muon Solenoid (CMS) collaboration that will run experiments at the LHC to explore the limits of conventional particle physics and to search for exotic phenomena like extra dimensions, supersymmetric particles, microscopic black holes, and new particle symmetries. FIU faculty and students are involved in the construction of the apparatus and will fully participate in some of the planned experiments. Participation of FIU is funded mainly by the CHEPREO grant which supports students, finances travel and infrastructure, and has enabled the department to hire additional staff and postdoctoral fellows.

4.1.4 New Trends in Optical Physics

Optical physics is another area of growth in physics. The field includes ultra-cold atomic physics, quantum information science and quantum electronics, and has important technological applications in quantum computing, the development of photonics and optical communication devices, bio-optical technology, laser technology, and materials processing. In particular, quantum information science and quantum computing have evolved into a multidisciplinary field involving optical physics, computer science and material science. Federal funding for these research programs has increased dramatically in recent years. Currently, the department has only one faculty member in optical physics, but with a very productive research program. Expansion of this group is one of the major goals of the department.

4.1.5 Physics Education Research

A relatively new, rapidly growing field in physics is physics education research (PER), which seeks to determine how students learn physics and to devise new methods for the effective teaching of physics at both the high school and university level. FIU has recently established a research group in this area through the support of the multi-disciplinary CHEPREO project, drawing on faculty in both the Department of Physics and the College of Education. The PER group is also supported by the Student Equity and Achievement in Mathematics and Science (SEAMS) and Physics Teacher Education Coalition (PhysTEC) grants, which, together with CHEPREO, provide support for two physics faculty members, two education faculty members, two coordinators and two graduate students. A particular strength of the FIU PER group is the opportunity at FIU to study physics education with groups that are largely underrepresented in physics.

4.2 Changes in Student Demand

Since the last program review, student demand for introductory physics and astronomy courses has continued to grow at a rate greater than that of university-wide enrollment growth. Evidence for this statement was presented in §3.4, p. 7, along with a discussion of its implications for the departmental student-to-faculty ratio. Data provided in Table 7 (§8, p. 22) are also instructive. The table shows the annual percentage FTE growth in various categories. Whereas the growth in upper division and graduate enrollments is mainly driven by recruitment efforts and the number of available graduate assistantships, the growth in lower division FTE production is in part due to overall university enrollment growth and, to this extent, is beyond departmental control.

4.3 Changes in Occupational Demand

One of the major driving forces of today's economy is its reliance on increasingly sophisticated technology. Physics is at the heart of this technology, and physicists are responsible for many of our modern technological innovations. Physicists also are important to many of the companies that bring new technologies to market. Evidence for the need for physicists abounds and we refer to the "*Rising Above the Gathering Storm*" report[4] for a comprehensive view of the important role physicists play in modern society.

4.3.1 Demand for Bachelor's and Master's Degree Recipients

Nationally, about 50% of all students who receive a terminal bachelor's or master's degree in physics go on to work in the private sector, while approximately 25% work in education (high schools, colleges and universities).[5]

For physics bachelor's and master's degree recipients who work in the private sector, the typical job held five years post-degree is in computer science and software (30%), engineering (20%), and in management or business ownership (20%). When asked which skills they use most in their jobs, over 90% of all degree recipients surveyed cited scientific problem solving as "very important," and 75% also reporting the ability to synthesize information as being "essential."[6]

Since the last program review, the need in many different fields for persons trained in physics has continued to grow. In particular, medicine and business are two areas that have experienced an increased need for physics-trained personnel. Many diagnostic and treatment methods employ radiological devices, magnetic and other resonance devices, and even particle accelerators, all of which require physicists and physics-trained technicians to develop and operate. With the approval of FIU's medical school program, the department has seen an increase in pre-medical students interested in double-majoring or minoring in physics (in the current semester, one biology, one mathematics and two philosophy majors are double-majoring in physics; one mathematics major is taking a minor in physics). Nationally, about one-third of physics students receive double-major degrees, combining physics with areas such as mathematics, engineering, computer and information science, astronomy and astrophysics, chemistry, philosophy and theology, music and the fine arts, biology, education, history and political science, the geosciences, and economics.[7]

4.3.2 Demand for Ph.D. Degree Recipients

Driven by the increasing societal demand for technology, one of the current areas of growth in physics is surface and materials science, especially nanotechnology. Biophysics is another area of national focus, as well as an emerging area of importance here at FIU with the addition of a medical school. To meet the emerging need for Ph.D. level scientists in these areas, the department has recognized these areas as high priority targets for expansion, see §4.1.1 and 4.1.2.

[4]Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, D.C.: The National Academies Press, 2007).

[5]American Institute of Physics (AIP) Statistical Research Center; http://www.aip.org/statistics/

[6]AIP Statistical Research Center; Ibid.

[7]AIP Statistical Research Center; http://www.aip.org/statistics/trends/highlite/career/career4.pdf

4.4 Changes in Societal Needs

4.4.1 Minority Representation in Technical Disciplines

A 2004 report on Education in Nuclear Science by the Nuclear Science Advisory Committee (NSAC)[8] notes that the current level of Ph.D. production in the nuclear sciences is not sufficient to supply the needs of universities, national laboratories and industry. The situation is particularly acute for members of groups traditionally underrepresented in the nuclear sciences, such as women, Hispanics and African Americans. The Department of Physics at FIU, with almost half of its faculty involved in nuclear and particle physics research, and with a large number of female and minority graduate students, is in a unique position to address these concerns. Research opportunities provided by the department allow these students to participate in the construction of new experimental facilities, to work with modern radiation detector technology, and to use advanced computing tools in data analysis and detector performance simulation.

4.4.2 Technically Trained Teachers in Public Schools

Closely correlated with the need for more physics-trained personnel in academia, government, business and medicine is a pressing need for more technically trained teachers in public schools. Without the motivation provided by well-taught science classes in middle and high schools, insufficient numbers of students will choose careers in physics, and the production of undergraduate and advanced degrees in physics will continue to lag behind demand. Through the CHEPREO project, the FIU Department of Physics has made efforts to address this need. These efforts are described in more detail in §5.1.6 on p. 16.

5 Strengths and Weaknesses

5.1 Strengths Supporting the Achievement of Program Goals

5.1.1 Research Diversity

One of the greatest strengths of the Department of Physics at FIU lies in the diversity of its research interests. For a department with fewer than 25 members, these research interests encompass an unusual breadth of disciplines, including astronomy and astrophysics, biophysics, experimental and theoretical nuclear physics (medium and high energy), optical physics, physics education research, and solid state surface and condensed matter physics. All members of the department are active in their respective research areas – publishing regularly in peer-reviewed journals (see Table 4, p. 16), attending professional workshops and conferences, reviewing manuscripts for professional journals, seeking and securing outside grant support (see Table 5, p. 16), and a variety of other professional activities. Such a diversity of interests and activities enhances not only the reputation of the department, but the university as a whole. It is a major factor in attracting quality students to the graduate program.

[8]DOE/NSF Nuclear Science Advisory Committee, Subcommittee on Education, *Education in Nuclear Science, A Status Report and Recommendations for the Beginning of the 21st Century*, Nov. 2004. Report available online at http://www.science.doe.gov/np/nsac/nsac.html.

The following is a brief overview of current research interests in the department and faculty (including rank) involved.

The **Astronomy** group has three faculty each working in different areas of astronomy. Associate Professor *Caroline Simpson* is a radio astronomer whose main interest is dwarf galaxies. Professor *Walter Van Hamme* specializes in the modeling of observables of eclipsing and spectroscopic binaries. Professor *James Webb* studies active galactic nuclei using data obtained with the SARA telescope and NASA space satellites. He is the director of the SARA telescope facility (see §5.1.2).

The **Biophysics** group consists of one experimentalist and two theorists. Professor *Richard Bone* studies the macular pigment of the human retina and conducts experiments related to the processing of information by the visual system. Professor *Bernard Gerstman* and Assistant Professor *Prem Chapagain* study the dynamics of protein folding, electron transfer in biological systems, ligand binding to home proteins, and laser induced retinal damage.

Elementary Particle Physics is a new research group created by the CHEPREO grant in early 2004 under the leadership of Professor *Pete Markowitz* and Associate Professor *Laird Kramer*. The group is involved in the development of the Compact Muon Solenoid (CMS) experiment (see §5.1.2). Visiting Assistant Professor *Jorge Rodriguez* joined the group in August of 2007 in a non-tenure earning line. The group also employs a Research Scientist, *Steve Linn.*

The **Nuclear Experimental Physics** group has five members, Professor *Pete Markowitz* and Associate Professors *Werner Boeglin, Laird Kramer, Brian Raue* and *Jörg Reinhold.* The group is leading a large program of experiments exploring the quark and gluon structure of matter at various accelerators, including the Continuous Electron Beam accelerator at the Thomas Jefferson National Accelerator Facility.

The **Nuclear Theory** group consists of Professors *Rudolf Fiebig, Oren Maxwell, Steve Mintz* and Associate Professors *Rajamani Narayanan* and *Misak Sargsian.* Interests of the group include weak interactions, nuclear astrophysics, nuclear reactions and the strong interaction, and the lattice field formulation of quantum chromodynamics.

The **Physics Education Research** group, created under the auspices of the CHEPREO grant, has two active members: Associate Professor *Laird Kramer* and Assistant Professor *Jeff Saul.*

The **Quantum Optics** group is the new incarnation of the former Atomic-Molecular-Optics group, after two of its members retired. Currently the group consists of one faculty member, Professor *Yifu Zhu*, who carries out experimental research in quantum optics.

The **Solid State Physics** group consists of three experimentalists, Associate Professors *Yesim Darici*, *Jiandi Zhang* and Assistant Professor *Wenzhi Li*, and one theoretician, Associate Professor *Xuewen Wang.* The group conducts theoretical and experimental studies of the structural, electronic and magnetic properties of metals, semiconductors, and complex materials.

5.1.2 Research Contacts and Affiliations

Aside from the diversity of its research interests, the Department of Physics has successfully established contacts and affiliations with major national and international research facilities.

The experimental nuclear physics group has a major presence at the **Thomas Jefferson National Accelerator Facility (TJNAF)**. The group contributes to the existing experimental program at that lab and is significantly involved in the planned upgrade of the facility (described in §4.1.3,

p. 9). Members of the group are co-spokespersons of eight active Jefferson Lab experiments, which they run collaboratively with numerous national and international institutions. Group members regularly serve on the Jefferson Lab User Group Board of Directors or other committees. Group members Markowitz and Reinhold have frequently visited the Proton Synchrotron Facility at the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan, where they participated in test experiments for the hypernuclear spectroscopy program at Jefferson Lab. This program is supported by significant equipment funds now totaling $5M from Tohoku University in Sendai, Japan. Through this collaboration, Reinhold and Markowitz also joined collaborations at the soon to be constructed Japan Proton Accelerator Research Complex (J-PARC) in Tokai, Japan.

An important part of the **CHEPREO** grant provides support for the development of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) at CERN. For a complete description see (§4.1.3, p. 9).

A number of workshops and conferences in theoretical nuclear and particle physics have been organized in part by members of the department and have taken place at FIU. These include (FIU faculty in boldface): *Hadrons in the Nuclear Medium*, March 7-10, 2000, **M. Sargsian, W. Boeglin** and M. Strikman (Penn State); *Topical Deuteron Workshop*, March 27-29, 2003, **W. Boeglin**, F. Gross (JLAB), **M. Sargsian**, P. Ulmer (ODU); *Lattice Hadron Physics Collaboration Meeting*, January 17-19, 2004, **R. Fiebig** and **R. Narayanan**; *Hypernuclear Workshop*, December 7-9, 2006, **J. Reinhold**, sponsored by Jefferson Lab; *Winter Retreat on Cold Dense Nuclear Matter*, February 15-17, 2007, E. Piasetzky (Tel Aviv), **M. Sargsian**, M. Strikman (Penn State).

The department is a member of the **Southeastern Association for Research in Astronomy (SARA)**[9] and makes major contributions both to the research programs of the association and its administration. The consortium operates a 0.9-meter telescope located at Kitt Peak National Observatory, Arizona. FIU has provided the directorship of the SARA Observatory since 1995. The astronomy group also utilizes the Very Large Array (VLA) radio telescopes in central New Mexico. For example, one of the astronomers (C. Simpson) is a member of the **LITTLE THINGS** team, headed by D. Hunter at Lowell Observatory. LITTLE THINGS (Local Irregulars That Trace Luminosity Extremes; The Nearby H I Galaxy Survey) is a multiwavelength study of a large sample of dwarf and irregular galaxies. The purpose is to determine how small galaxies form stars to shed light on how the universe has evolved. The project has been granted close to 376 hours of observation time at the VLA, one of the largest time allocations ever granted and one of only 30 “Large Projects” to be awarded in the past 16 years.

Since 2001, the astronomy group has organized two international conferences: *Exotic Stars as Challenges to Evolution*, March 4-8, 2002, **W. Van Hamme**, R. E. Wilson (UF), sponsored by the International Astronomical Union (IAU) as IAU Colloquium 187; *Blazar Variability Workshop II: Entering the GLAST Era*, 10-12 April 2005, **J. R. Webb** and H. R. Miller (Georgia State), sponsored by NASA.

The materials physics lab (MPL, led by J. Zhang) and nanomaterials group (led by W. Li) currently maintain active research collaborations with **Oak Ridge National Laboratory (ORNL)** and the **University of Tennessee-Knoxville**. The research concerns the study of correlated electron

[9]Consortium consisting of 10 universities: Florida Institute of Technology, East Tennessee State University, Florida International University, University of Georgia, Valdosta State University (GA), Clemson University (SC), Ball State University (IN), Agnes Scott College (GA), University of Alabama, Valparaiso University (IN). Operational funding is provided by initial, one-time institutional fees and subsequent annual membership fees. FIU’s annual fee of $10,000 is paid from the Department of Physics annual budget.

materials and nanomaterials using neutron scattering techniques. With the world's highest flux reactor-based neutron source (the High Flux Isotope Reactor, HFIR) and the world's most intense pulsed accelerator-based neutron source (the Spallation Neutron Source, SNS), ORNL provides neutron scattering capabilities unavailable anywhere else in the world. Additional research is conducted in collaboration with the **University of Tokyo**, the **National Institute of Standards and Technology (NIST)**, **Brookhaven National Laboratory**, the **University of Kassel** in Germany, the **Institute of Physics** at **Beijing University**, the **University of Nebraska**, and **Boston College**. Note that all these collaborations include research training of graduate students and are an important graduate student recruitment tool. Professor Zhang also serves on the Scientific Advisory Board of the **State Key Laboratory for Surface Physics** and he is a visiting professor at the **State Key Laboratory of Optical Physics**. Both of these are **Chinese Academy of Science** laboratories.

The theoretical biophysics group has recently initiated a collaboration with the **Institute of Non-Newtonian Fluid Mechanics** at the **University of Swansea** in the United Kingdom. This collaboration is sponsored by the Royal Society.

The optical physics group (Y. Zhu) collaborates with the **Institute of Physics and Mathematics** of the Chinese Academy of Sciences and with the **State Key Laboratory of Precision Spectroscopy** at **East China Normal University**. Professor Zhu was also a visiting professor at the **Institute of Optics, Information and Photonics** at the **University of Erlangen**, Germany.

This array of research connections and affiliations greatly enhances the research productivity of the department by providing access to major experimental and observational facilities and by providing contacts with other researchers in the research disciplines pursued at FIU. The opportunity to work at major research facilities and to collaborate with physicists outside FIU is also a major factor in attracting graduate students to the department.

5.1.3 Research Productivity – Publications

The number of publications in peer reviewed journals produced by the department per academic year, including the number of papers per faculty, are listed in Table 4. Note that not only has the annual publication output of the department increased substantially since the last program review, but also the annual publication output per faculty member. Currently, the department's publication record compares very favorably with that of other physics departments at benchmark institutions, as demonstrated in the report produced by Academics Analytics, LLC, described in §2.6 on p. 4.

5.1.4 Research Productivity – Grant Support

Funding data for the department since the last program review are provided in Table 5. Since 2001, departmental grant support has increased significantly and is now at the level of almost 2.5 million dollars per annum. Most of this funding is provided or has been provided by federal agencies such as the National Science Foundation, the Department of Energy, the National Institutes of Health, the U.S. Air Force, the National Aeronautics and Space Administration, the Department of Education, the Office of Naval Research, the Department of Defense, and the Army Research Office. Enhanced

Table 4: FIU Physics Annual Peer Reviewed Publications

	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
No. Faculty	20	21	21.5	20	20	21
Gross No. Papers	38	41	64	78	57	73
Gross Papers/Faculty	1.90	1.95	2.98	3.90	2.85	3.48
Net[a] No. Papers	29	33	43	54	41	50
Net Papers/Faculty	1.45	1.57	2.00	2.70	2.05	2.38

[a]Papers with multiple authors from the department counted only once.

Table 5: Physics Department External Funding

Fiscal Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Number of Proposals Submitted	16	15	26	16	17	14
Number of Submitters	12	13	13	8	11	14
Total Funds Requested	4,737,327	7,915,329	8,127,616	2,889,413	5,718,434	2,592,110
Average per Proposal	796,083	527,689	312,601	180,588	336,378	185,151
Average per Submitter	394,777	608,871	625,201	361,177	519,858	185,151
Number of Proposals Funded	20	14	21	18	21	15
Number of Awardees	12	14	18	11	15	13
Total Amount Funded	1,142,259	1,332,340	3,850,214	1,191,434	2,171,580	2,396,455
Average per Award	57,113	95,167	183,343	66,191	103,409	164,033
Average per Awardee	95,188	95,167	213,901	108,312	144,772	176,650

grant support benefits the department in a number of ways. It directly contributes to faculty research productivity by providing funds for travel to major experimental and observational facilities and by providing salary support so that faculty members can pursue summer research interests full time, rather than part time. It also allows the department to increase graduate student enrollment by providing research assistantships. Finally, it enhances the reputation of the department and the university by providing favorable exposure of FIU to granting agencies and by providing funds for travel to international conferences where FIU faculty can present their research results and interact with other researchers in their fields.

5.1.5 Department Research Ranking in the Academic Analytics Survey

The department's ranking in the Academic Analytics, LLC, survey is described in §2.6 on p. 4.

5.1.6 Initiatives in Education, Student Recruitment and Outreach

Through the CHEPREO project, the department supports new teaching methods of physics and participates in the recruitment and mentoring of undergraduate students in physics. Over the course of five years, a learning community has been established that includes over 120 members, including 90 high school teachers. These teachers have attended intensive, three-week long guided-inquiry workshops based on the physics modeling method, which they then apply in their classrooms to improve the instruction of their students. At the university level, the department offers several sections of studio-based introductory physics classes using the modeling method. These courses have been very successful, in terms of student learning outcomes, faculty assessments, and recruiting.

The impact of CHEPREO on student recruiting has been significant. The department has experienced substantially increased enrollment in upper division physics classes over the past few years (see Table 7, p. 22). For example, enrollment in the Modern Physics class, an indicator of how many new physics majors are starting in the program, has more than tripled. Many of these students were recruited from the modeling classes and many have ties with the high school teacher community created by CHEPREO.

The department has been involved in outreach to the local community for over 15 years. A popular public lecture series and regular sky viewing events (star parties) are attended by people from all walks of life, including many students grades 1 to 12, community college students and their teachers. These events have enhanced the department's visibility within the university and outside in the local community.

The SARA consortium is a National Science Foundation sponsored Research Experiences for Undergraduates (REU) site. The department participates in this program by hosting two to three undergraduates each Summer for a ten-week research internship. Participating students are selected via a nationwide and competitive search.

5.2 Weaknesses Impeding the Achievement of Program Goals

5.2.1 Small-size Research Groups

While one of the major strengths of the department is the diversity of its research activities, several of its research groups are below optimal size. Two groups in particular, while very active, are hindered in their activities by their small sizes. The quantum optics group has only one member, despite the high priority the department has placed on increasing the size of this group. Since the last program review, the experimental solid state group has increased from two to three members, but given the wide diversity of research activities in solid state physics, this number is still well below optimal size. Moreover, the group has only one theorist, a number which has remained constant over the past 17 years. Below-optimal group sizes negatively impact research in several ways. The number of graduate students that can be accepted within a group is limited by the number of available research advisers. In fields like quantum optics and solid state physics, which have attracted a lot of student interest in recent years, the department has been forced to turn away a number of qualified graduate students. Limited group sizes also limit the number of contacts the groups have with outside organizations, thereby limiting the number of outside research collaborations, and make external grant support more difficult to secure. A final argument in favor of avoiding small-size research groups is a recent finding published in the journal *Science*:[10] teams typically produce more frequently cited research than solo researchers do. This conclusion is based on citation records of close to 20 million papers published in the last 50 years in science and engineering, the social sciences and the arts and humanities. Regardless of discipline, there is a clear trend towards increased impact of team vs. individual research.

[10]Stefan Wuchty, Benjamin F. Jones and Brian Uzzi, "The Increasing Dominance of Teams in Production of Knowledge," *Science* 316 (2007): 1036-1039.

5.2.2 Lack of an Astronomical Observatory

A significant part of the total FTE production of the department comes from the two introductory (core) astronomy courses (20 to 25% of lower division FTEs). The major educational goal of these courses is to introduce students to the basic principles of science, through the discipline of astronomy. Central to this goal is hands-on experience with real astronomical observing using telescopes. In addition to its contribution to departmental FTE productivity, the astronomy group is engaged in outreach activities such as public lectures and sky viewing with departmental telescopes. Unfortunately, the department has lacked a viable site for carrying out these public observing activities for nearly its entire history. Originally, the student observatory was located on top of the Chemistry-Physics (CP) building, but this location was made untenable because of modifications to building roof structures. A new observing pad was built on the north-east side of the CP building, but that location is now compromised by the installation of new outdoor lighting and soon to be constructed new buildings. This lack of a viable observing site has adversely affected the astronomy educational programs and the quality of public outreach activities. The good news is that we expect these issues to be resolved soon. A substantial private donation to construct a college observatory is in the process of being secured.

6 Opportunities

In this section we look at some opportunities the department is interested in pursuing in the near future.

6.1 New Research Contacts and Affiliations

One of the strengths of the relatively small FIU Physics Department is the number and extent of its research contacts and affiliations with other research institutes (see §5.1.2 on p. 13). A major opportunity for the department, at relatively little expense, is to expand upon these affiliations and to use existing contacts to develop new ones.

One example is the collaboration between FIU's materials physics group (J. Zhang) and the proposed Tennessee/Louisiana Flagship Materials Laboratory, to be developed by the University of Tennessee-Knoxville and Louisiana State University. Federal funding for the creation of this laboratory has been requested from the National Science Foundation through its Materials Research Science and Engineering Centers (MRSEC) program. Professor Zhang is a co-investigator on this proposal.

6.2 Establishment of Research Centers

The diversity of research interests in the department makes several disciplines prime targets for the establishment of a multidisciplinary research center. Specialized centers with research themes that span several disciplines are ideal vehicles for boosting external funding and creating new faculty lines in a department. They enhance the visibility of the university nationally and internationally.

One area of physics that is particularly suited to the establishment of a research center is nanoscience, including nanomaterials and nanodevice engineering. Such a center would involve a partnership of the condensed matter and nanomaterials group in the department with research groups in the College of Engineering and Computing and related off-campus groups. The goal would be to establish either a State or federally funded Center of Excellence for materials research and education that would exploit the status of FIU as a minority university and existing contacts with Oak Ridge National Laboratory, especially its Laboratory for Nanophase Materials Science and Spallation Neutron Source.

6.3 Enhanced Contacts with the Local Education Community

The department has significant contacts within the local education community, a large part of which were established through the CHEPREO project (see §5.1.6, p. 16). The department has also established relations with the Miami-Dade County Public School administration, both at the district level and at individual schools, and with other schools and districts. The PhysTEC grant (see §4.1.5, p. 10) presents us with a unique opportunity to establish a joint Department of Physics-College of Education program for training high school physics teachers.

7 Threats to Achieving Program Goals

7.1 Loss of Faculty

Despite recommendations in the last program review, the Department of Physics at FIU has not expanded in size. While a number of new faculty members have been added since 2001, their numbers have been offset by departing faculty, either through retirement (two retirements since the last review), moves to other institutions (two faculty, with one other faculty member accepting a counter offer and deciding to stay at FIU), or a move into administration (one faculty). With the adoption of the Delaware Study (DS) as one of the components of FIU's Faculty Allocation Matrix (FAM), adding new faculty has proven to be a challenge.

If one compares FTE productivity and faculty size of the department with that at comparable institutions, it is quite clear that the FIU Department of Physics is significantly understaffed. As discussed in §3.4 on p. 7, the department has experienced an average increase of 24 student AFTEs per year since 2001. Correlated with this increase is the AFTE-to-faculty ratio, which has increased steadily at a rate of 1.14 AFTE/Faculty/year from a value of 14.2 prior to 2001 to a value of around 20 currently (down from a peak value of 22 in 2005-06). These data are fully corroborated by the 2003 DS ratios for physics (CIP code 40.08). The DS Research 75%-quartile benchmark student-to-faculty ratio for physics is 15.4, compared with 22.3 for the FIU Department of Physics. To reduce the FIU ratio to that for the 75% quartile of benchmark institutions would require the addition of 6.8 FTE faculty. To bring the FIU ratio in line with the 50% quartile benchmark ratio would require 12.5 additional FTE faculty.

Other data that enter FIU's FAM are FIU/BOT and BOG priority levels for the discipline. Here it should be noted that Physics (CIP 40.08) is on the BOG list of "Targeted Programs for Increased Degrees." If the Physics Department is evaluated in the FAM at BOG and BOT/FIU priority levels *commensurate with its presence on the targeted program list*, we expect Physics to rank sufficiently high to warrant additional faculty lines.

The possibility of a prolonged flat or even declining faculty size constitutes a real threat to the viability of the department. Not only would it prevent the expansion of existing research groups, which is necessary for the evolution of the department toward greater national recognition and for attaining very high research activity status in the Carnegie ranking, but it would stifle the infusion of new ideas and new research interests that new faculty members bring to a department. If one examines physics departments across the country that have failed to replace departing or retiring faculty members, one inevitably finds departments in decline, with decreasing graduate enrollment, decreasing grant support, and decreasing research activity. This is not what we would like to see happen at FIU.

7.2 Faculty Salaries

Faculty salary compression is another important factor that affects faculty morale. Table 6 contains summary data collected in the National Academic Physics Salary survey for the 2006–07 academic year. This survey is performed annually by Florida State University and represents salary data collected from physics departments at 83 U.S. universities, including several institutions in the Florida State University System. While starting salaries for new faculty members in Physics at FIU

Table 6: Average Physics AY 2006–07 salaries per Faculty FTE

	New Ass. Prof.	Ass. Prof.	Assoc. Prof.	Prof.
Nationwide	65,566	65,818	73,869	104,152
FIU Physics	65,920	64,296	71,202	85,091
FIU Physics Rank[a]	21	44	47	73

[a]A total of 83 U.S. universities participated in the survey.

are near the national average, the salaries of more senior members of the department, professors in particular, are far below the national norm, and even below the state norm (the average Florida SUS Physics Professor salary in 2006–07 was $96,595, 11.5 K$ above FIU's average). For the three ranks combined, FIU Physics salaries fall $7,337 short of the national average. Salary compression also manifests itself in large salary disparities among faculty at the same rank or between ranks, with some higher ranked faculty earning substantially less than more junior colleagues.

7.3 Graduate Student Support

Since the last program review, the department has increased both the number of grant-supported Research Assistant (RA) and college-supported Teaching Assistant (TA) lines (see Table 1 , p. 6). Compared with physics programs at benchmark institutions, however, FIU Physics continues to underperform in the number of graduate students it supports and limits the number of students that can be admitted into the graduate program. Because graduate students, particularly doctoral students, actively contribute to the research programs of the various groups, a low number of graduate students has a negative impact on a department's research productivity. Teaching productivity also suffers as fewer TAs are available to teach introductory laboratory courses or to provide other course assistance. A small graduate student population also means fewer graduates who contribute to the reputation of the department and who motivate other students to consider attending FIU. This is a particularly significant point in relation to international students among whom word-of-mouth recommendations frequently play an important role in student recruitment.

7.4 Space Allocation

Despite improvements since the last program review, lack of space continues to be a challenge. In particular, a lack of adequate space for undergraduate labs is expected to become a vexing problem in the near future. Rooms assigned to these labs have a limited number of experimental stations and students per station. Along with the limited number of TAs available to teach lab sections, these limitations restrict the total number of introductory laboratory students that can be accommodated each semester. The solution will have to be two-pronged: identification of new space and redesigning the laboratory experience so as to utilize existing space more efficiently.

Office space for graduate students is also a critical issue. While all current graduate students have some minimal space assigned to them, new students often have to wait a semester or more to acquire any office space at all. This impacts graduate student morale and makes it difficult for lower division students to contact their lab instructors, thus negatively impacting the quality of teaching in the department.

7.5 Administrative Research Support

The level and quality of administrative research support provided by the university has generally been regarded as substandard. The inefficient system of grant budget administration during the transition to an online accounting system has been particularly challenging. Serious efforts by the Office of Sponsored Research Administration and the College are underway to address these inefficiencies. Soon we expect to enjoy grant support services worthy of very high research activity universities.

8 Budget

In this section we present a five-year projection of incremental costs and revenues for the department. We address increases in FTE production, expected incremental indirect cost (IDC) return from grants, and the added financial requirements of proposed faculty and staff additions, graduate assistantships and space needs. Our cost and revenue assessments are based on a number of specific assumptions regarding enrollment growth, grant support, and new faculty/staff lines.

Before making projections into the future, we need to look at the past. Table 7 lists student FTE annual percentage growth for the past five years both for FIU as a whole and the Department of Physics individually. In each category, the five-year average FTE growth for the department has exceeded that of the university. For the next six academic years (2007-08 through 2012-13), FIU has adopted annual percentage FTE growth rates of 2.5% each for lower and upper division enrollment, 5% for graduate I and 7% for graduate II enrollment (the latter increasing to 8.2% in 2011-12 and 9.5% in 2012-13). Target FTE production numbers for the Physics Department (Table 8) are based on these figures, *except* for upper division and graduate FTEs. For upper division FTEs a rate of increase of 5% per year has been adopted. The rationale for this includes anticipated pay-offs from undergraduate major recruitment efforts and the establishment of new programs for physics

Table 7: FIU and Physics FTE Percentage Growth: 2001-07 Actual

	2002–03	2003–04	2004–05	2005–06	2006–07	Average
PHY Lower Division	+11	+6.0	+2.1	+16	−2.8	+6.6
FIU Lower Division	+3.6	+2.9	+7.1	+11	+2.6	+5.4
PHY Upper Division	+0.0	+11	+20	+0.0	−8.3	+4.6
FIU Upper Division	+2.8	+2.1	+2.6	+5.0	+5.0	+3.5
PHY Graduate	−5.6	+18	+10	−4.5	+14	+6.4
FIU Graduate	+7.4	−4.4	−1.1	+2.6	+6.9	+2.3
PHY Total	+10	+6.7	+3.0	+14	−1.2	+6.5
FIU Total	+3.8	+1.3	+3.6	+6.7	+4.3	+3.9

teachers (see §6). For graduate FTE projections we are guided by the goal of building a first-rate

Table 8: Physics Projected FTE Production and FTE Faculty Needed

	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	< % >
Lower Div.	397	407	417	427	438	449	2.5
Upper Div.	12	12	13	13	14	15	5.0
Graduate	26	29	32	36	41	43	10
Total	435	448	462	476	493	507	3.1
S/F Ratio	19.8	18.7	17.8	16.4	15.4	15.4	...
FTE Fac.	22	24	26	29	32	33	...
Fac. Needed	...	2	2	3	3	1	...

research department commensurate with very high research activity status in the Carnegie ranking. Therefore, the projected numbers of additional graduate students scale with the projected numbers of new faculty through the assumption that each new faculty member will develop a successful research program with two graduate students, one supported by C&G, the other by E&G funds. This translates into an average 10% annual increase in the number of graduate FTEs produced by the department. Finally, the projected numbers of new faculty have been obtained by requiring that the FTE student-to-faculty ratio decreases linearly from the current level of 20 to the average value of 15 for benchmark institutions in the 2003 Delaware Study. Table 9 shows annual incremental costs and revenues based on these and additional assumptions outlined in the footnotes to the table. The incremental cost of new faculty, staff and graduate assistantships is offset by incremental FTE generated revenue and grant indirect costs.

The anticipated need for $3M in start-up funds over the next 6 years is substantial but realistic if very high research activity status is desired for FIU. The indirect cost return numbers in Table 9 are based on the expectation that each new faculty member will generate $200,000 in grant support, including 40% in indirect costs, in FY 2007-08, and that this figure will increase by 3% each subsequent year. These figures are consistent with past Physics Department grant support, as indicated in Table 5 on p. 16.

Space requirements are expected to be met in part by the addition of an astronomy tower which is planned to have at least four 125 sq. ft. offices and which will also free up 390 sq. ft. of space in CP that can be converted to lab space. The Physics Department also has approximately 1,700

Table 9: Physics Projected Incremental Costs and Revenues

	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	Total
FTE	12	13	14	16	16	13	
Rev./FTE[a]	11,500	11,845	12,200	12,566	12,943	13332	
State Rev.	138,000	153,985	170,805	201,062	207,094	173,311	1,044,257
Fac. Needed[b]	...	2	2	3	3	1	
Sal./Fac.[c]	85,425	87,988	90,627,	93,346	96,147	99,031	
Total Salary	0	175,976	181,255	280,039	288,440	99,031	1,024,740
Staff Needed[d]	0	0	1	1	0	0	
Sal./Staff	0	0	35,000	60,000	0	0	95,000
GA in-state	0	1	1	2	2	1	
GA out-of-state	0	1	1	1	1	1	
GA Cost[e]	0	60,195	62,001	89,635	92,324	67,750	371,906
C&G/Fac.	140,000	144,200	148,526	152,982	157,571	162,298	
IDC % rate	40	41	42	43	44	45	
F&A/Fac.	56,000	59,122	62,381	65,782	69,331	73,034	
Total F&A	0	118,244	124,762	197,346	207,994	73,034	721,381
No. Exp. A[f]	0	1	0	0	1	1	
No. Exp. B[g]	0	0	1	2	1	0	
No. Theor. [h]	0	1	1	2	1	1	
Start-up	0	550,000	350,000	650,000	850,000	500,000	2,900,000
Off. space	0	250	250	375	375	125	1,375 sq. ft.
Lab space	0	1,000	500	1,000	1,500	1,000	5,000 sq. ft.

[a]State funding of $11,500 per AFTE in 2007-08, annual 3% increase thereafter

[b]From Table 8

[c]2007-08 base AY salary of $67,000 + 27.5% fringe, 3% annual increase thereafter

[d]One additional clerical staff member and one grant accounting person, fringe included.

[e]2007-08 stipend of $18,000 per year and $5,587 (in-state) or $16,855 (out-of-state) tuition; 3% annual increase thereafter.

[f]Experimentalist, $500,000 start-up, 1,000 sq. ft. lab space, 125 sq. ft. office

[g]Experimentalist, $300,000 start-up, 500 sq. ft. lab space, 125 sq. ft. office

[h]Theoretician, $50,000 start-up, 125 sq. ft. office

sq. ft. in existing space available for conversion to research lab space. Over the next five years, the net need will be for 875 sq. ft. of office and 3,000 sq. ft. of research lab space. The amount of extra teaching laboratory space needed is not yet clear and depends on how well we will be able to optimize space currently available, and how quickly the university will commit additional space in the Viertes Haus to the CHEPREO project.

9 Recommendations

Put the department back on a healthy faculty hiring track. We recommend adding faculty lines according to the budget plan outlined in §8, starting with the high-priority areas of optical physics, biophysics, solid state/condensed matter and astrophysics. Also, adding a faculty position in high-energy/elementary particle physics in AY 2009-10 has to be planned as per CHEPREO grant conditions. Expansion of existing groups is crucial if the department is to achieve its goal of becoming a top-tier physics department. New faculty will broaden the research interests of the groups, bring in new grant support, contribute to increased research output, and attract new and better graduate students.

Increase the number of graduate assistantships allocated to Physics by 50% over the

next five years. This will allow graduate student enrollment to grow and reach a level commensurate with that of typical Carnegie Research University/Very High Research Activity institutions. This goal is fully in line with the university goal of becoming one of the top ten urban, public research institutions in the nation by the year 2015. Reaching this goal will require doubling the number of doctoral degrees currently produced by FIU from 100 to 200 per year by 2015. Physics is fully prepared to play its role in achieving this goal. Expanded graduate student enrollment will not only enhance research productivity but also allow the department to increase the number of laboratory sections offered in conjunction with introductory courses in physics and astronomy.

Explore the feasibility of establishing two Centers of Excellence, one in nanoscience and one in biophysics. A strong nanoscience center with faculty members from physics, engineering and chemistry will create greater research efficiencies through shared resources and enhance the research viability of participating groups. A biophysics center will be able to exploit synergies among the fields of physics, biochemistry and medicine and raise FIU's research profile in this area.

Hire one or more instructors in physics and astronomy over the next two years. One or more non-research instructors qualified to teach both introductory physics and astronomy will enable the department to distribute teaching loads more effectively and lower teaching loads for high-productivity research faculty. An additional benefit will be a reduction in the need for adjunct instructors.

A Student Learning Outcomes

Student Learning Outcomes for the Physics B.S. and B.A. programs, including direct assessment measures, are presented in this appendix. Data for the Physics ALCs have been obtained for the first time during the Spring semester of AY 2006-07. Results and follow-up plans are listed in the fourth and fifth columns in each of the panels.

Florida International University: Student Learning Outcome Assessment

Department: Physics Chair: Walter V. Van Hamme Year: 2006-07

PROGRAM NAME & CIP CODE: Physics 400801 LEVEL: BS

Expanded Statement of Institutional Purpose	Learning Outcomes	Assessment Measures & Procedures	Outcome Assessment Results	Use of Results for Program Improvement
The Bachelor of Science program prepares students for careers as professional physicists in industry or government. It also helps prepare students for teaching careers or graduate study in physics or engineering. The intent is to educate undergraduate majors with an understanding of basic concepts and laws of nature; to provide undergraduates with experience in performing active research; to teach undergraduates effective communication skills; and to develop critical thinking skills.	Demonstrate basic content knowledge and analytical skills in the following areas: mechanics, electricity and magnetism, thermodynamics, and quantum/wave mechanics	Students will take the Education Testing Service (ETS) Field Exam in Physics during their senior year. 70% of students should score at the 50th percentile on both the basic and advanced level.	At the basic level, 50% of students scored at or above the 50th percentile. At the advanced level, 75% of students scored at or above the 50th percentile.	The high percentage of students that scored above the 50th percentile at the advanced level reflects favorably on the quality of the education we offer. We will work to improve the basic level course experience, for example, by trying to reduce the number of adjunct teachers of such classes, or through other programmatic changes.
	Demonstrate understanding of experimental methodology	To be evaluated by Modern Lab and Senior Lab faculty using a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	89% of students scored 2 or better on the three point rubric.	Lab instructors will continue to look for opportunities to improve the lab experience, for example new lab activities, new experimental setups.
	Apply basic experimental techniques	To be evaluated through in-class observations by Modern and Senior Lab faculty using a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	89% of students scored 2 or better on the three point rubric.	Lab instructors will continue to look for opportunities for students to design their own experiments.

Expanded Statement of Institutional Purpose	Learning Outcomes	Assessment Measures & Procedures	Outcome Assessment Results	Use of Results for Program Improvement
	Apply basic theoretical techniques	To be evaluated in all required upper division lecture courses through homework and exam problems. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	We will look for ways to make course content relevant to current themes in physics.
	Demonstrate the ability to effectively use technology through the use of scientific instrumentation to gather scientific data	To be evaluated through in-class observations by Modern and Senior Lab faculty using a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	89% of students scored 2 or better on the three point rubric.	We will continue to pursue a goal of well-stocked laboratories with modern tools, equipment and computers.
	Apply abstract critical thinking and experimental methodology using physics principles to diverse and applied physical systems	Students will be evaluated through homework, presentations and/or exam problems in all required upper division lecture courses. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric. Students will also be evaluated with questions from the faculty reviewer during presentations in the Senior Lab class. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric. 89% of students scored 2 or better on the three point rubric.	We will seek to integrate physics education research-based techniques into upper division courses, inspired by success of similar techniques adopted in lower division courses.

Expanded Statement of Institutional Purpose	Learning Outcomes	Assessment Measures & Procedures	Outcome Assessment Results	Use of Results for Program Improvement
	Demonstrate the ability to work independently on physics projects that are experimental or theoretical in nature.	To be evaluated by faculty who teach Independent Study, a course of which students are required to take at least 3 credits. Faculty will evaluate students' ability to conduct independent research, provide written reports and/or oral presentations. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	We will engage a broader segment of the faculty to serve as independent study mentors so as to create a wider range of opportunities.
	Design, carry out, and analyze results from an experiment	Faculty teaching the Senior Lab course will evaluate the students' ability to design, carry out and analyze an experiment using a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	78% of students scored 2 or better on the three point rubric.	Lab instructors will look for opportunities for students to design their own experiments.
	Ability to make a conference-style oral presentation of an undergraduate research project to peers and department faculty.	Senior Laboratory is a required course for the degree and class presentations of projects are a standard course practice. Instructors evaluate students using departmental presentation rubric. 70% of students will score a 2 or better on the three point scale.	89% of students scored 2 or better on the three point rubric.	We will use these results to encourage faculty to include student oral presentations as part of their course curriculum.
	Ability to explain in writing, the results of an experiment	To be evaluated by Senior Lab faculty from lab reports and presentations. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	Faculty will provide students with critical feedback on how to write professional style reports.

Expanded Statement of Institutional Purpose	Learning Outcomes	Assessment Measures & Procedures	Outcome Assessment Results	Use of Results for Program Improvement
	Operational Objectives:			
	Graduating Seniors seeking to apply to graduate programs will be accepted.	70% of graduates applying to graduate/professional school will be accepted into a graduate program.	8 out of 8 students applying for graduate school were accepted.	We will fine-tune mentoring efforts to better prepare students for the transition into graduate school.
	Graduating seniors seeking employment will be offered a job.	70% of graduates seeking employment will be offered a job associated with their skills.	One student seeking employment was offered a job.	We will inform students about career opportunities for terminal BS degree recipients.

Florida International University: Student Learning Outcome Assessment
Department: Physics   Chair: Walter V. Van Hamme   Year: 2006-07

PROGRAM NAME & CIP CODE: Physics 400801   LEVEL: BA

Expanded Statement of Institutional Purpose	Learning Outcomes	Assessment Criteria, Standards & Procedures	Outcome Assessment Results	Use of Results for Program Improvement
The Bachelor of Arts prepares students interested in physics and who plan to enter professional schools in business, education, journalism, law, and medicine, and for liberal arts students desiring a strong background in physical science but with career objectives in other areas. The intent is to educate undergraduate majors with an understanding of basic concepts and laws of nature; to teach undergraduates effective communication skills; and to develop critical thinking skills.	Demonstrate basic content knowledge and analytical skills in the following areas: mechanics, electricity and magnetism, thermodynamics, and quantum/wave mechanics	Students will take the Education Testing Service (ETS) Field Exam in Physics during their senior year. 70% of students should score at the 50th percentile on both the basic and advanced level.	At the basic level, 0% of students (1 student) scored at or above the 50th percentile. At the advanced level, 100% of students (1 student) scored at or above the 50th percentile.	Results will only become meaningful when more statistics have been accumulated. We will work to improve the basic level course experience, for example by trying to reduce the number of adjunct teachers of such classes or through other programmatic changes.
	Apply basic theoretical techniques	To be evaluated in all required upper division lecture courses through homework and exam problems. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	We will look for ways to make course content relevant to current themes in physics
	Demonstrate the ability to effectively use technology through the use of scientific instrumentation to gather scientific data	To be evaluated through in-class observations by Modern and Senior Lab faculty using a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	We will continue to pursue a goal of well-stocked laboratories with modern tools, equipment and computers.
	Apply abstract critical thinking and experimental methodology using physics principles to diverse and applied physical systems	Students will be evaluated through homework, presentations and/or exam problems in all required upper division lecture courses. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	We will seek to integrate physics education research-based techniques into upper division courses, inspired by success of similar techniques adopted in lower division courses.

Expanded Statement of Institutional Purpose	Learning Outcomes	Assessment Criteria, Standards & Procedures	Outcome Assessment Results	Use of Results for Program Improvement
	Ability to give an oral presentation of an undergraduate project to peers and department faculty	Widely Applied Physics I and II are required courses for the degree. WAP II will require a presentation. Instructors evaluate students using a departmental presentation rubric. 70% of students will score a 2 or better on the three point scale.	100% of students scored 2 or better on the three point rubric.	We will use these results to encourage faculty to include student oral presentations as part of their course curriculum.
	Ability to explain in writing the results of an experiment	To be evaluated by Modern Lab and/or Senior Lab faculty from lab reports. Evaluation will be based on a three point departmental rubric. 70% of students will score a 2 or better on the three point rubric.	100% of students scored 2 or better on the three point rubric.	Faculty will provide students with critical feedback on how to write professional style reports.
	Operational objectives:			
	Graduating Seniors seeking to apply to graduate programs will be accepted.	70% of graduates applying to graduate/professional school will be accepted into a graduate program.		
	Graduating seniors seeking employment will be offered a job.	70% of graduates seeking employment will be offered a job associated with their skills.		