

**Florida Atlantic University
Physics Department
Program Review
March 8 & 9, 2015**

**Review Team:
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OVERVIEW

The team of Dr. Peter Saulson, Dr. Charles Torre and Dr. Ali Zilouchian reviewed FAU's Department of Physics on March 8-9, 2015. Dr. Warner Miller, Ex-Chair of the Department, provided the reviewers with a self-study and Ms. Lynn Sargent, the Executive Assistant to the Dean provided a detailed itinerary and exemplary logistical support. Additionally the review team met with:

- All members of the Department faculty in two separate meetings (tenured, tenure track and instructors)
- Michele Hawkins, Associate Provost
- Camille Coley, Associate Vice President for Research
- Russell Ivy, Interim Dean of the College of Science
- Ingrid Johanson, Senior Associate Dean of the College of Science
- Evonne Rezler, Assistant Dean for Assessment at the College Science
- Ed Pratt, Dean of Undergraduate Studies
- Susan Fulks, Associate Dean of the Graduate College
- Debra Szabo, Assistant Director of the Graduate College
- Warner Miller, Professor and Ex- Chair of Physics Dept.
- Luc Wille, Professor and Interim Chair of Physics
- Graduate and undergraduate students in Physics.

The Department of Physics offers undergraduate programs leading to the Bachelor of Arts (B.A.) and Bachelor of Science (B.S.) degrees. At the graduate level, the Department offers Master of Science (M.S.), Master of Science in Teaching (M.S.T.) and Doctor of Philosophy (Ph.D.) degrees. In addition, the Department offers a newly-accredited professional graduate program in Medical Physics leading to the Professional Science Master (P.S.M.) degree. The research within the Department is primarily concentrated in two areas (i) General Relativity and Gravitational Physics and (ii) Biomedical and Materials Physics. In addition, the Department provides great service to the university and the professional community as well as engaging the local South Florida education community by offering a number of outreach programs designed to stimulate interest in physics.

The reviewers studied several documents including the Self-Study Report, previous external and internal reviews (2001 and 2009), a memo on recent BOG performance funding model metrics, and the current draft of FAU's strategic plan. The current review focuses on the Department's strengths, challenges and future potential as aligned with the Department/College mission and the FAU strategic plan.

In addition, the review addresses the Department's educational and research sustainability, and the prospects for its expansion into several multidisciplinary research and educational areas, including experimental physics and medical physics. The Department possesses a great opportunity to "move up" to the next level, in collaboration with other Departments within CESCOS, the College of Medicine, the College of Engineering and Computer Science and several university centers.

These issues are discussed below and the review team provides some suggestions in the final sections of the report. More formally, the review team was asked to deliver the following:

1. A brief assessment of the areas addressed in the self-study that it is believed are the most salient for purposes of improvement
2. A response to the questions at the end of the self-study that the Department requests be addressed.
3. A list of recommendations, in the form of action plans, that should be considered to take the program to the next level of standing. NOTE: Recommendations will be embedded into the answers to the questions as well as the assessment section.

STRENGTHS and ACHIEVEMENTS

The review team was able to discern a number of definite strengths and achievements of the FAU Physics Department, each of which leads to excellence in their program. The Department should be commended for these achievements and, presumably, build on them as they strive for continuous improvement. We summarize the salient strengths and achievements below. We have no doubt that with additional time devoted to the on campus visit, we would have identified still more successes and accomplishments. The salient strengths/achievements of the FAU Physics Department are as follows.

- *A world-class spacetime physics research group (FAUST)*

This is a purely theoretical (as opposed to experimental) research endeavor. Currently, four of the nine tenure-line faculty participate in this group: Beetle, Engle, Miller, and Tichy. The common core to these individuals' research specializations is Einstein's general theory of relativity, but the scope of what this group does is relatively broad, ranging from computational approaches to gravitational theory and related geometric structures, to mathematical aspects of relativity, to the quantum nature of the gravitational field.

The principal measures used to determine excellence of such a research group normally include publication quality, external funding, and research community impact. The publication record of the group is very solid, with substantial papers appearing in top-notch journals. Three of the four members of the group enjoy a significant amount of external funding from Department of Defense (DoD) and National Science Foundation (NSF). Competition for theoretical physics grants from these sources is keen, and acquisition of such grants is normally considered a strong indicator of a successful research program. To give a proper assessment of research community impact would require an analysis which is beyond the scope of this review, but the sum total of quality of publications, external financial support, and a solid portfolio of well-known collaborators world-wide strongly suggest that this impact is indeed significant. The quality of this group is also reflected by their ability to attract a relatively strong cohort of graduate students.

The review team is of the opinion that the caliber of the FAUST faculty and the quality of the work done in this area would be considered as excellent and highly valued in any research intensive institution.

- *A recently established, already substantial Medical Physics MS program*

The Professional Science Master with major in Medical Physics is an applied physics program which nicely complements the theoretical nature of the FAUST group. It is an accredited professional MS program which leverages community involvement via partnerships between FAU and four major Hospitals/Cancer Centers in both Palm Beach county and Broward county. Well-recognized medical physicists in the field of radiation therapy who are appointed as Adjunct/Research Affiliate Professors in the Physics Department provide the students with the opportunity of clinical training and research on one-to-one basis.

Already a sizable fraction of the graduate students in physics are involved in this program. The Medical Physics program provides an applied alternative to the heavily theoretical specialization acquired by graduate students involved with the FAUST program. The distinct emphases for physics training, for research experience, and the robust job market subsequent to degree which are provided by this program are all well documented and assessed and provide a necessary heterogeneity to the department.

It is remarkable that this program has been created more or less single-handedly by one of the physics faculty. An upcoming hire will further support this new program, and it appears that there is substantial potential for further growth in the near future.

- *High quality instructor group*

The degree to which non-tenure line faculty are used to support the mission of a physics department varies considerably across the country. The Department of Physics at FAU teaches a large (if typical) number of students in its lower level classes and laboratories, principally to support other programs, e.g., engineering. The number of tenure line faculty is small compared to typical physics departments which have a substantial graduate program and which serve this many lower division students. Consequently, the non-tenure line faculty carry a comparatively large fraction of the department's teaching load. The majority of the instructor ranks possess a PhD in physics and significant experience in teaching the lower level courses and laboratories. It was clear from our interviews with the non-tenure line faculty that the instructors are highly skilled and are dedicated to providing a high quality education for FAU students. We noted that some of the instructors had successfully sought funding for improvement of the teaching laboratories and observatory, which underscores the positive impact of the non-tenure line faculty on the department.

RESPONSES TO QUESTIONS

1. Are there any particular physics-specific measures or definitions of student success that you use in your department, and how do these measure the effectiveness of the various innovations and initiatives promoting student success?

One reasonably effective approach to addressing such issues is to define a clear and detailed set of learning outcomes which characterize what a student should be able to do upon graduation with a physics degree. It is tempting to create learning outcomes which are essentially just unions of sets of outcomes for individual courses, but a better approach tries to define skills that characterize the degree as a whole and which a student

can realistically be expected to still possess after graduation. Such outcomes are normally created in tune with some kind of systematic assessment method. While it is always a challenge to adequately assess such outcomes without spending inordinate resources, a portfolio of successful strategies often includes: capstone courses (e.g., a senior project) which involve most if not all of the desired outcomes and where student performance is tracked systematically; exit interviews with graduating seniors; tracking of students' progress post-graduation. These are just suggestions/examples, of course. Each program has to find the methods that work best for it.

2. What are effective strategies for increasing research grant funding in general relativity for our FAUST group, and for our effort in Medical Physics?

FAUST: Make a connection with LIGO activities.

Medical Physics: Add faculty here – this program needs more personnel to increase its resource base.

3. What is reasonable staffing (faculty, student) for the 60 sections of instructional laboratories in the department?

Based upon the (admittedly anecdotal) experiences of the review team, the level of staffing for instructional laboratories currently being used by the Physics Department at FAU is well within national norms.

4. What do you view as the top three critical issues for our department?

- Give renewed attention to the student pipeline and graduation rate of the undergraduate program.
- Grow the medical physics program.
- Augment the physics faculty with strategic hires (on the tenure track) that support the educational and research missions of the Department.

These are discussed in more detail in the Recommendations section.

5. How can we enhance student retention of lower-level UG physics majors; should we increase admission requirements for our department?

There are 45 upper division (juniors and seniors) undergraduate students majoring in physics during spring 2015 according to the latest data from IEA. 49 upper division students have declared physics as their major for fall 2014 semester. Although, the total number of undergraduate students for the physics major increased significantly from 42 (Fall 2010) to 70 (Fall 2014), the graduation rate for such a pipeline is relatively very small (4 graduates/year), which is lower than the BOG graduation rate guideline/require-

ment for the sustainability and health of the program. It was the review team's impression (and it is only an impression) that improved undergraduate retention is not so much contingent upon increasing standards as it is upon enhanced engagement of the faculty and staff with students at all levels of the undergraduate program especially at the senior level. Some ideas for doing this are described in the Recommendations section.

6. Can we be a viable department in the field of physics without an experimental component?

It would appear that from a purely research-based point of view this is feasible. Indeed, the department is doing this now to a considerable extent. The review team is of the opinion that this scenario is not sustainable in light of the educational mission of the department, particular from the point of view of the undergraduate program.

7. How might we recruit more US students for our undergraduate and graduate degree programs?

This is a challenging question, of course, with which we all struggle. Obviously there is no simple answer. However, the review team's recommendations suggest some ideas here.

From a purely undergraduate point of view, if the program can be enhanced along the lines discussed in the recommendation section, then a larger & more vibrant undergraduate cohort will naturally attract additional students from FAU. If an undergraduate medical physics type of option is created for FTIC or transfer students with AA degree from State Colleges, then of course a whole new set of pipelines for potential students in physics is created.

Ideas which ought to be relevant for both undergraduate and graduate programs include the following.

* Spend a little more time on improving and continuously updating the departmental website. Admittedly, this is a relatively superficial thing to focus on. But the fact is that the first place most students go to see if they are interested in a program is the relevant website. If there are no "hooks" which are easily found there, then that is the end of that. Highlighting student activities on the front page of the website, along with items advertising the research results/activities of faculty are often effective hooks.

* If, hopefully, additional faculty can be hired in experimental areas, and if these new programs can be successfully advertised to potential students (e.g., via the website) then this should go a long way toward addressing the question posed here.

* Faculty recruiting visits to institutions where prospective students reside can be very effective.

8. How do we effectively advertise our strengths to the wider academic community (one of the largest GR groups in the country, our newly accredited PSMMP program with superior results of our students passing the ABR exams)?

We do not know of any secret weapons here. We can only suggest the tried and true methods for getting the word out: conference presentations, hosting conferences, institutional visits, hosting visitors, the department website.

SALIENT AREAS

The Department's self-study provided a wealth of information on the state of its educational and research programs. There is much to be proud of.

The self-study enabled us to understand the state of the Department today. In our discussions with various stake-holders during our visit, it became clear to us that there were several areas that were the focus of attention for continued development and improvement of the Department. Using all of this information, we decided that our recommendations would be most useful if directed at these areas of interest. They are: the health of the undergraduate program, the role of Medical Physics, and the narrow focus of faculty research.

RECOMMENDATIONS

The Review Committee offers three key strategic recommendations, based on what we learned during our visit. None of them originated with us; instead, each one reflects desires and plans that we learned of from members of the Physics Department. We do hope nevertheless that these recommendations will help the Department to give shape to its plans.

Our recommendations are to:

- Give renewed attention to the health of the undergraduate program.
- Grow the medical physics program.
- Augment the physics faculty with strategic hires (on the tenure track) that support the educational and research missions of the Department.

Below, we discuss these three recommendations in more detail.

- Give renewed attention to the health of the undergraduate program

FAU is blessed with many students who are interested in majoring in physics, but the graduate rate is below the minimum target of the State University System. The BOG criteria for the minimum number of the graduates for BA/BS program is 30 students for 5 years. However, the Dept. graduated only 21 students for the past five years. In addition, the Dept. graduated 12 Ph.D. students for the past 5 years. Given the current Ph.D. student pipeline (31 during spring 2015), it is anticipated that the Dept. will easily meet the minimum of 3 Ph.D. graduate per year (BOG guidelines) in the future years. We sensed a strong desire to remedy this situation, and we believe that success is within reach.

We met with about a dozen motivated and articulate physics majors. They are proud to be FAU physics majors, but they did share several valuable ideas for strengthening the program. One would be to include in the required Bachelor's program a course in computation, as a way to build a skill that is both central to research as well as a marketable skill in its own right. In addition, the students are clamoring for more access to research experiences. We believe that both of these suggestions are excellent ones, and are ones that the Physics Department should be able to satisfy.

A computation course has been discussed, and undergraduates are invited to enroll in the graduate computational physics course with a modified syllabus especially focused on their needs. However, students told us that they are asked to pay a substantial bump in tuition because the course is formally at the graduate level. They also reported difficulty fitting it into their programs, given the heavy burden of their other requirements. We think that the Department needs to find ways to address these obstacles, given the importance of meeting this key educational goal for its students.

Making available to all students a meaningful research experience is equally important, but somewhat more challenging to achieve. Nevertheless, it is essential for a complete Physics education. We understand that, given the small size of the faculty, this asks each of T/TT faculty to take on at least one (if not several) students. Since almost all members of the faculty are theorists, not experimenters, there's an extra challenge of finding research projects at the appropriate level. But this is a challenge that has been met at other places – learning and adopting best practices from elsewhere should make it possible to achieve. Of course, if the Department is successful in augmenting its strength with some new experimental faculty (see our recommendation on that subject) that will both share the burden and also make a wider variety of research experiences possible.

We strongly urge that both of those student requests be met. Would doing those two things ensure that more students graduate each year? No, but they would motivate students more and help them to achieve their own educational goals; that additional morale would surely help the work of attracting more strong students to the major.

We also believe that there are two other initiatives that the Department could take to strengthen the undergraduate program, in combination with the above.

One initiative would be to **strengthen faculty advising for undergraduates**. By this, we don't mean that students need more help in choosing courses; the professional

advisors in the Charles E. Schmidt College of Science do a fine job, and Dr. Korey Sorge makes a faculty connection to the students as well. But it seems that there is an important advising function that is not yet being met, but that could make a major impact. At many universities, undergraduates meet with a faculty advisor in their major each semester, and we urge that this practice be adopted by the FAU Physics Department. At some institutions, this is required as part of the registration process every semester, enforced by the registration software. We understand that this mechanism may not be available at FAU. Nevertheless, the building of a personal connection between individual faculty members and individual students is invaluable, for a number of reasons. Mentoring of students can take place this way, with a level of personal connection that is hard to duplicate in other ways. Faculty members come to understand the personal challenges that students face; this both helps them to help the individual student in front of them, but also informs thinking about what changes to the program might be needed in order to address student needs. We were struck by the inability of FAU faculty to understand or explain the puzzling fact that there are many more physics majors at the senior level than the number who graduate each year. If faculty met regularly with student advisees, it is much less likely that a fact like that would be mysterious. We think it likely that more students would succeed, simultaneously helping them as individual human beings while also increasing the graduation rate which is used as such a central measure of success.

Our other recommendation would be to **leverage the remarkable and laudable success of the Medical Physics Masters' Program with some strong connection to medical physics at the undergraduate level.** We aren't sure exactly what form that might take, but we expect that the Physics Department would find the form that works best at FAU. Perhaps it might be a formal five-year B.S. – M.S. degree track in physics, or it might be a bachelor's only track (officially labelled as such or not) in which students replaced some of the more advanced upper level physics courses with courses in other subjects, perhaps ones already taught at FAU in other departments, that gave students a good preparation in medical physics. Or, there might be yet another better way to achieve this goal. The key point, though, is to build on the knowledge that medical physics is something that the Department has learned to do well, and that responds to a recognized need and strong desire in the community and in the student body.

We strongly believe that each of these four initiatives would be valuable in its own right, and responds to the Department's own understanding of what it could do to strengthen its own already strong program. We also believe that it is highly likely that, if all four of these initiatives were carried through successfully, the graduation rate of physics Bachelors would increase substantially. This would allow the Physics Department to balance its already remarkable achievements in research and in graduate education with the mark of success in undergraduate education that everyone at FAU hopes they can achieve.

- Grow the medical physics program

We were very impressed with the success of the Professional Science Masters' in Medical Physics program. It has grown rapidly, and clearly meets a strong need in the community and among students.

We learned that the program could enroll substantially more students, and thus serve the community better, if the faculty grew beyond the hire just being made now. It seems clear that FAU should follow up its initial success with further investment. As long as there is further student demand for the degree and market demand for its graduates, it would be a shame not to take the actions that would allow that natural and desirable growth to occur.

As we noted above, we think that the success of the Medical Physics program can benefit the undergraduate program in physics as well. Medical Physics is an applied field that could have justified appeal to a cohort of undergraduates who don't yet know that they ought to major in physics. Even for those already interested in physics, this particular application can be interesting, a valuable part of a well-rounded physics education. The net result should be a larger number of graduates, who graduate with broader knowledge and more understanding of the range of choices open to physicists.

For all of these reasons, we recommend that the faculty of the Medical Physics program be allowed to grow to meet the so-far-unmet demand.

- Augment the physics faculty with strategic hires (on the tenure track) that support the educational and research missions of the Department

We are extremely impressed with the very high quality of the research program of the Department, and of the Ph.D. program associated with it. This is all the more remarkable given the very small size of the tenured/tenure-track faculty, among the smallest in the country of programs that offer the Ph.D. degree.

This very high quality and productivity notwithstanding, the mix of research areas is seriously unbalanced and rather narrow. Of course, the major investment in gravitational physics is highly laudable, and has resulted in one of the strongest such groups in the country. However, students at both the undergraduate and graduate level are calling for a broader range of research topics to be represented, especially experimental research. The faculty too are very aware of their needs in this area.

It is, of course, completely understandable that experimental hires have been de-emphasized in a time of tight budgets, since the cost of equipping a new experimental laboratory is substantial. But the lack of opportunities in experimental physics research is dramatic enough that it severely impairs not only the research program of the Department but also its educational mission, at both the undergraduate and graduate levels.

We were impressed by the range of creative ideas brought forward by Department faculty for addressing this problem. Those ideas shared a key feature that is necessary for success: finding ways to partner with other successful units at FAU, in directions aligned

with the emphases in the new FAU Strategic Plan. Everyone recognizes that large investments won't be available for initiatives that solely benefit the research program of the Physics Department. But to the extent that the Physics Department can contribute its special brand of expertise to University-wide priorities, then everyone benefits. Not least will be the benefits to students at all levels.

It is beyond the expertise of this Review Committee to endorse any specific hiring initiative. Nevertheless, we endorse very strongly the general principle that the Department needs to find a way to help the whole University succeed while augmenting its own strength in one (or even better) several experimental fields, through strategic hires in cooperation with other units.

CONCLUSION

The Physics Department is doing a superb job pertaining to research as well as offering many sections of IFP (service) courses at the UG level. The Department has recently established a medical physics program with great success. The Department needs to pay attention particularly to the health of the undergraduate program, and grow the Medical physics at both UG and G levels. The Department could be bolstered by the addition of one/two tenure track faculty hiring in experimental physics in alignment with the university-wide priorities and through collaboration with other units within CESCOS and other Colleges and several university centers.