Report of the 2010 Academic Program Review External Committee on the Department of Physics and Astronomy, University of New Mexico.

The recommendations of the Committee are in italics

1. Members of the Academic Program Review External Committee

Donald Backer (University of California, Berkeley)
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The Committee received a charge from the Vice Provost for Academic Affairs; Wynn M. H. Goering dated January 21, 2010. The Department provided copies of the Self Study and Long-Range Plan as well as access to a number of documents.

A winter storm in the North East prevented Prof. Banavar from joining the visit and delayed Prof. Orozco one day. Prof. Banavar shared with the committee his thoughts based on the self-study via e-mail, and he is co-author of this report.

The Committee followed the schedule prepared by the Office of the Dean, but on the last day we toured the building in detail, looking at laboratories, offices, machine shop, electronics shop, and utility rooms. We also had a long talk with the Chair before the closeout session with the Provost, Deans, faculty senate representatives, chair, administrative officers of the Department, chair of the self-study committee, and others.

2. Academic State of the Department:

We are very pleased with the quality of the programs that the Department is offering. They take care of their undergraduates who were very positive and upbeat about the quality of education they were receiving. It is impressive that close to 50% of the undergraduates participate in research projects during their stay, and we encourage the Department to increase this level of participation even further.

The Department shows great concern for the graduate students and has organized the curriculum of the basic courses with a realistic approach to overcome deficiencies in the undergraduate preparation of the graduate students.

The current teaching load of the faculty is appropriate and should not increase, as it would start to jeopardize the research enterprise. The teaching load is comparable to that at similar state universities.

Undergraduate Committee:

We talked to the Undergraduate Committee and found them well engaged in their task. They said that on average the typical undergraduate takes five years to finish the degree requirements. This lengthy time to degree is mostly due to difficulties with algebra and mathematics, a problem that comes from high school.

They have struggled to convince the Mathematics Department to offer courses better matched to physicists than to mathematicians. The Department offers for example a concentration (minor) in optics and is analyzing other avenues, for example biophysics.

It would be good to develop an undergraduate course in Biological Physics. In general, without some sort of introduction, undergraduates in physics do not have any understanding of what biophysics is or of the opportunities available for graduate work and a future career in biophysics. During our discussions with the undergraduates, it was clear that such a course would be welcomed. Of course, making such specialty courses available (not only in biophysics) takes a special effort of the faculty, and might not always be possible considering other teaching loads and finances. However, courses and highly active seminar programs are excellent recruiting tools to attract both graduate and undergraduate students, internally as well as externally, to a vibrant biophysics program. This is especially true for biological physics, because many students with a solid physics background do not have any background in biophysics, let alone biology.

We recommend that the Department pay constant attention to their website as this is their face to the world especially to any undergraduates considering majoring in physics. It is very important that the web page has recent news from the Department, and that these items are updated regularly.

The Department has gone through a series of formats for the advancement exam, they seem happy with the results it has given. Some members of the Committee see that the current format takes time out of the research for the students, and it is probably a handicap in recruiting. They find the process too long (three years) and suggested that a different approach could be taken to ensure that each graduate student has mastered the basics of the undergraduate curriculum, but requiring less time from the students and the faculty; for example requiring that all students pass the Physics GRE exam with certain grades on each section by a particular date, or by asking each student to take the exam when they come into the program (first test and then teach), and suggesting a sequence of courses to remedy any deficiencies.

The balance between affordable laboratories and interesting laboratories is difficult to achieve, but the Department should offer some 21st century experiments, for example some related to quantum information. Among the service courses for non-science majors, the department should consider offering one on energy, a topic of increasing importance.

Undergraduate students:

We had the opportunity to meet with an enthusiastic group of undergraduate

students. Some of the current undergraduates did not arrive originally at the Physics Department, but their interaction with physics faculty through the initial courses, convinced them to change majors. They expressed love and appreciation for the Department and for the faculty members that mentor and guide them. They stressed that their professors are excited about their subject and that this excitement is contagious.

They pointed out that they all felt a big quantitative and qualitative change between the 200 and the 300 level courses. They expressed their frustration at the matching of the mathematics courses they have to take with physics courses that are supposed to use those topics.

The undergraduate students commented that several of the math courses they took were not useful to their curriculum because they came too late, or that they had to learn the math during their physics classes. The Physics Undergraduate Committee seemed to be considering an option where they would offer one of the math courses within the Physics Department. Since engineering faces similar problems with math courses, there was a suggestion that the Physics Department should work with the Engineering School to determine if such a course could be developed and offered jointly between engineering and physics – perhaps Mathematical Methods for Physicists and Engineers. Other universities (for example UIUC and UMD) have such a course and it is successful.

It would be good to have more active announcements of courses in other departments that may be interesting/relevant to the undergraduates; e.g., a listing on the undergraduate information web page. The offerings of special topical courses do not always match their calendars, and knowledge of courses offered elsewhere can alleviate covering the breadth that the students should have at the end of their undergraduate studies.

Graduate Committee:

The major discussion with the graduate committee involved how to attract highly qualified students and the preliminary (advancement) exam. The committee explained that they have dealt with the preliminary exam over the last several years and as a result of several trials settled on the present system as the best for their graduate students. The committee felt that to prepare an exam every semester in the four fields takes a considerable amount of faculty time if the exams are to be carefully constructed.

The major advice of the Academic Program Review Committee for attracting students was to have an exciting, up-to-date web site, with thorough explanations of the present research in the faculty, designed and maintained by a professional. Impressive web sites are especially attractive for modern students, and the web is their major source of information. Announcements by mailed fliers are helpful mainly to guide future students to the web sites. The graduate committee concurred, and it was evident that investigation into how best to improve the web site was already under consideration. Of course the normal activities, such as visits during recruitment, are necessary and being done. In this regard, more regular advanced specialized courses may also attract highly

qualified graduate students, if it is clear to incoming students that these opportunities are available on a regular schedule. However, the main attraction for incoming students is the faculty and the research topics. The specific opportunities of UNM Physics and Astronomy should be highly visible on the web site.

The Department offers a course in Biological Physics at the graduate level. This should be offered every year to acquaint all new students with an interest in biological physics. A mature biophysics program requires that students develop not only good physics training, but also acquire a solid biology background. Most good students recognize their shortcomings, and while they may be attracted to biological physics, they are especially attracted to a program that presents a solid formal training, and where they see that there is also an active seminar program. These considerations can be critical for the future of a biophysics program in a physics department, because good students are a prerequisite for a strong research program.

Graduate students:

During the meeting with the graduate students it was clear that the students were happy with their education and opportunities provided by the Department. The major topic of the conversation dealt with the qualifying examination. The reason for the exam is to be sure that the students have a solid knowledge in all areas of an excellent undergraduate Physics program. The general feeling was that too much time was spent on preparing for this exam. Even within the bounds set by the requirements of the department, it could take up to three years to pass all sections of the exam. This extended time can interfere with the progress of the students on research, and hinder the concentration of the students in their field of choice. It was the majority opinion of the Academic Program Review Committee that it might be better to "test and then teach", rather than have an extended period of exams. That is, the exams could be given either when the students arrive, or within the first year. Based on the results of the exam, the students would be required (or advised) to take appropriate courses (these could be advanced undergraduate courses or even appropriate graduate courses) that would minimally cover the material where the student underperformed. This would make it possible for students to concentrate earlier and more vigorously on their research, and would also save time for research.

Another wish voiced by some students was that specialized courses, as well as new topics courses, could be offered more often. It was clear that in some cases it was not possible for some students to take advanced courses in their area of specialization until a significant time after they started their research. This was also discussed in the meeting with the graduate committee. Upon discussion it became clear that this low frequency of certain advanced course offerings was mainly due to the already high teaching duties covered by the Faculty. However, the committee still considers this an important issue, and emphasizes that the topic be considered by the graduate committee. Perhaps a solution could be found at least for a few courses that would benefit a larger number of the graduate students on a more regular schedule.

The Department should be aware that more funding agencies, including the NSF starting this year, are requiring scientific ethics training for all graduate students supported by the grant. We recommend that the Department organize this for all students instead of having the individual PI prepare each one individually.

Postdoctoral researchers:

We had the opportunity to talk in private with two current postdoctoral researchers that expressed their enthusiasm for the department and the opportunities they have had thanks to the resources at the University and at Los Alamos.

The Department should be aware that starting this year the NSF requires a mentoring program for Post-Doctoral associates supported by new grants. It would be good to have a coordinated program for all departmental post-doctoral associates.

Staff:

The morale of the staff during our interview was contagiously up beat. They expressed their appreciation of the chairman and the faculty. They stated that they were the happiest staff on campus, despite the state of the building and some of their difficulties with central administration.

Diversity:

The University of New Mexico at Albuquerque is in a unique position to attract the Hispanic population. We commend the Department for its efforts along this line. It is vital that the department pay great attention to all underrepresented groups (women and minorities) already present in the Department as well as those that they hope to attract in the future.

We recommend that the Department contact the American Physical Society to arrange a visit to analyze the climate for women and minorities. The visit will help the Department find new ways to move forward beyond what they are doing now on this area, in particular because of its unique geographical situation in the country.

3. The self-study document

The committee has found the self-study document very valuable. It shows a clear vision of where the Department is at this point in time, and where it wants to be in the future. We congratulate the Department for producing it as it has made our work easier. This document should serve as the starting point for the next internal self-study in six or seven years.

The document makes reference to the priorities and issues in the past round and identifies the actions that have been taken to bring them to closure. In particular the study provides clear set of priorities for essential new hires. Our Committee supports their

choices.

4. Science:

During our visit to the Department we had the opportunity to talk with the individual groups to both look at their scientific achievements and plans, together with their needs and frustrations. We like what we saw in terms of quantity and quality, and we hope our recommendations enhance and facilitate the good things and solve some of the problems.

Astronomy and Astrophysics:

The realm of astronomy & astrophysics (A&A) extends from understanding the origin of the Universe to the development of complex molecules that serve as precursors for life. The techniques employed range on the observational side from radio to gamma-ray instruments and now gravitational wave detectors; and on the theory side from abstract thought to exquisite simulations. A&A overlaps increasingly with particle physics, high-energy physics and nuclear physics discussed in the following section. Each informs the other, and the Department faculty with its small size and close quarters appears to recognize the positive synergy of frequent interaction. This discipline is one of constant discovery and new developments, which is attractive to students in learning basic principles of the scientific method as well as engaging in their first research experiences.

The undergraduate courses offered are well subscribed and cover the material. With a small faculty group and small graduate student incoming classes it is difficult to cover the breadth of material needed to introduce students to the field. The faculty has made good choices as best we can see. This includes use of classes that bridge undergraduate and graduate student levels. They do need to be allowed here as in other areas to proceed with small class enrollments as availability of instruction affects attractiveness of UNM to prospective students.

The group should be applauded for their public outreach. Astronomy is popular and straightforward to bring to the public, young and old. The faculty seems to enjoy this extra activity that connects them to the community. The observing telescope facility is critical to this activity – it is essential to "see" the stars, and not just hear about them with slick projections and accompanying lectures. UNM as a whole benefits.

Observatories are laboratories for astronomers and UNM needs to support access to observatories if they are to keep and attract the best possible faculty. In particular, UNM made a commitment toward a radio observatory initiative, the Long Wavelength Array (LWA). The LWA provides a unique observatory experience: faculty and students both develop and use a new facility. The depth of learning from the development of a new facility is profound in comparison to the often more routine effort of analyzing data from an existing observatory. The LWA effort appears to be in serious jeopardy from both external and internal support; UNM could lose ground gained in their A&A program

with the 2005 hires of Taylor and Pihlström if the LWA does not succeed.

The goal of hiring a theorist in A&A is excellent to complement existing strength on the observation side. The Committee did not discuss the possibilities that might arise with the move of the Space Weather group from Hansom AFB to Kirtland, which was reported in their self-study. New Mexico is rich in A&A and related basic research groups. UNM can build strength through strategic partnerships with these institutions in this area as well as others mentioned in this report.

Particle Physics:

Particle physics has had a very visible presence in the Department since the 1970s. What is impressive is how the Department successfully responded to changes in nuclear and particle physics to create the current group balanced between heavy ion, collider and particle astrophysics. The research covers what, arguably, are the intellectual frontiers of particle physics today: relativistic heavy ion physics, the Large Hadron Collider, cosmic ray, neutrino physics, and the search for dark matter. Particle astrophysics represents excellent opportunities for collaboration with Los Alamos as illustrated by the ongoing search for a new member of the faculty.

Quantum Information:

The success in securing financing for the Center for Quantum Information Science by the NSF confirms the high quality of its members and the recognition they have among the members of the community. The recent departure of their youngest member is a very hard blow to their program. The hiring plan identifies a Quantum Optics experimentalist as a top priority together with a quantum information theorist. Reaching a number of four faculty members should enable them to broaden their influence on the new field of quantum information. Their impact has been large, their former students and postdoctoral associates are positioning themselves worldwide in institutions that have identified this area as high priority. Since UNM has been a leader in this every effort should be made to maintain and grow in this area.

Optics:

This is one of the pillars of the Department. The group carries out its research in the physics building and attracts close to one third of the current graduate students. It is a joint program with engineering that is one of the top five in the country. It has had great success and impact, but the faculty is ageing and is in need of new members. The long-term plan identifies an optics theorist as one of its top priorities.

Although this unit will have its own external visit soon, it is important to clarify its administrative and academic identity to have better lines of communication with the administration. This group has been affected directly by the problems of the building.

Biophysics:

The field of biological physics is a rapidly growing sub discipline in physics departments the world over, and in accordance with this development, the Department began an initiative several years ago to expand their biophysics presence. This was definitely a good and timely move. Two senior faculty members have been active in the biophysics field for some time: Prof. Thomas is experimental and Prof. Kenkre is theoretical with other very broad interests in many different research areas, especially condensed matter. Biological physics is nowadays undoubtedly a valuable part of any vibrant physics department, especially considering the enormously rapid advancement in our understanding of molecular and cellular biology, which presents exciting opportunities and challenges for experimental, theoretical, and computational physicists (particularly in the fields of the experimental biophysicists in the faculty). In recognition of this, they have hired two assistant professors in the last several years; if the financial climate improves they have plans to add another faculty member in biological physics area; however, this hire is not imminent. The research fields of the new biophysical hires have overlapping interests with the optical group; this was apparently done deliberately with the foresight that that both disciplines would profit from this, and in the future would lead to new collaborative research initiatives. Especially considering the expertise of the optical group, such collaborations should be further accentuated; it provides a distinctive opportunity for unique research. On account of the research interests of the biophysicists, close ties (including shared hiring) and apparently fruitful collaborations have been developed with the university Cancer Center and the Center for High Technology Materials. In addition, during conversations with the faculty it was clear that the biophysical faculty realize their unique advantage of contacts with Los Alamos and the Sandia laboratories.

There is no one in computational biology directly in the Department. Although it would be good to have a faculty member who could collaborate with the experimental biophysicists in the Physics Department, this can be alleviated through contacts with Los Alamos. But computational biology is a rapidly growing research area that requires more than only computational and computer engineering skills (that is, a broad and concentrated knowledge of biological systems is critical for future success). The nearness of Los Alamos would certainly attract faculty as well as students interested in computational biology. A very healthy sign of the vitality of the biological physics emphasis in the Department is the interest and participation of Physics' faculty in other disciplines in biological problems.

Condensed Matter and Statistical Mechanics:

Condensed matter physics is a burgeoning area of physics that is closely related to several other sub-fields. There are three tenured and three research faculty in this area. The strength of this effort lies not only in the high quality work but also in the synergies and collaborations it fosters. One faculty member has important links with engineering, while another has built up a tremendous reputation for interdisciplinary research through the enviable Consortium of the Americas for Interdisciplinary Science. It is vital that the Department build on the strengths of this group, which could have intellectual affinity

with the quantum information group.

5. Answers to Questions

Elective courses:

During our interactions with the administration, the Deans and associate deans of the college stressed their willingness to facilitate offering elective courses both to graduate and undergraduate students even when the number of registered students does not reach the required threshold number of students. The Committee thanks the administration for this and notes that these kinds of courses are very important for preparing exploring new biophysics degrees or concentrations.

The building:

The committee had opportunity to tour the building in detail to look at the current status. We found that there are very serious problems that jeopardize the high-class research currently under way in the Department. The temperature control of the building is completely inadequate; on a good day the change in temperature is about 4 F, while on a bad day it can reach ten to twelve degrees. This makes the operation of many instruments, for example lasers, very cumbersome. The researchers have made heroic accommodations in their experimental approaches to deal with this, but we find that this is not the best use of their resources. The temperature problems are compounded with dust that enters into the building through some of the mechanical and electrical rooms, as well as the HVAC system.

It is clear from the construction and the materials that the building is not energy efficient. This is a cost to the university that will only increase as time passes.

We urge the University to move as fast as possible on the design and construction of a new building to house the Physics and Astronomy Department. The design should incorporate among other things, efficient and effective ways to control the temperature and humidity environments of the laboratories as well as appropriate electrical power with high quality grounds and shielding from electromagnetic radiation (cell phone towers, etc.) and magnetic noise. The building should have significantly better energy efficiency.

In the future it will be necessary to provide laboratory space within the Physics and Astronomy Department that is conducive for wet chemistry and biochemistry. Although this has been unusual for traditional physics departments in the past, this will be necessary in the future in order to attract the best biophysics faculty and graduate students, as well as to train both graduates and undergraduates. This should be considered whenever a new building becomes financially possible. Supplying such laboratory space will support the cohesiveness of the biophysics students, as well as the faculty as a whole, and will lead to collaborations within the faculty, for instance with the optical group. At the moment many of the wet lab facilities are located in other places.

On the other hand, not all wet lab facilities need be directly in the Physics and Astronomy department, and arrangements with other departments is often necessary, and desirable, for specific laboratory facilities, such as cell growth and maintenance of biological specimens (this is already taking place).

Electronic and machine shop:

We strongly support the idea of retaining the electronic and the machine shop staffed with professional people. There are other models applied, but given the size of the Department, and the current areas of research, we recognize that the one-on-one interaction with the staff is invaluable for the advancement of the projects. These shops also function as a kind of institutional memory that is very necessary for the long term health of the Department. There are also very important for retention and recruitment of top experimental faculty.

Merit raise:

We recommend not using any pre-established formula for merit increases.

6. Further recommendations:

During many of our interactions with the Department the question of how to better attract graduate students surfaced. We realize that the current state of the building is a handicap to attract graduate students; the offices where they are housed are not welcoming.

The length of time for advancement to candidacy can be having an influence in attracting graduate students. It may be interesting to consider our recommendation about using the Physics GRE exam for this assessment, as is currently done at institutions such as the University of Texas at Austin.

We recommend that the Department strengthen the connections with Sandia National Laboratory and with Los Alamos National Laboratory and explore the creation of highly attractive fellowships (at the level of NSF graduate fellowships) for prospective UNM graduate students. Improvement of the ranking of the Department is a task that takes many years, a clear vision, and stewardship. This Committee sees that the Department has a vision and stewardship and would stress the need to secure the construction of a new building as a priority to the UNM administration to increase the ranking of the Physics and Astronomy Department. The Department should strengthen and augment its links to Sandia and Los Alamos, both national laboratories. We recommend exploring the establishment of joint institutes that enhance the exchange not only of ideas, but also of resources, that can then improve the quality of the graduate students who will carry out projects under the dynamic leadership of the Physics and Astronomy faculty.

Respectfully submitted on April 11, 2010 by The Committee