Five Year Plan for Department of Physics 2016-2021: 2017 update

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As derived based on discussions leading up to and during a department retreat, January 15, 2016. Updated February 7, 2017 with 2017 retreat results.

1 Department Overview

The Physics Department at NM Tech includes 11 tenured/tenure-track faculty, 1 lab manager/teaching faculty, 1 administrative assistant, and approximately 25 graduate students and 80 undergraduate majors. The departments inception and historical development of both the undergraduate and graduate degrees in Physics date back to the post World War II era during the time of President E. J. Workman. Areas of concentration in the department today are primarily categorized into atmospheric physics and astrophysics, split nearly equally across the faculty members. 25% of the faculty are women, which is a high percentage in the U.S. for Physics Departments according to the American Institute of Physics. Four of our faculty are involved in building instrumentation associated with their scientific concentrations. In the past 9 years, 21 Ph.D.s and 28 M.S.s have been completed. Additionally, a total of 106 BSs in Physics have been awarded, 42 with specializations in one of the departments core areas (and a large fraction of our B.S. recipients also double major or minor in other departments). While these numbers of students, and the faculty to student ratio, are solid and have remained fairly stable over the past 20 years, we believe that it is possible today to support somewhere between 2 and 3 graduate students per faculty member, and undergraduate class sizes of roughly 25-30 per year. This would suggest that the department could raise its student enrollment to 28-32 graduate students and 100-120 undergraduates. We outline some growth areas below and how we plan to accomplish these goals in the next few years. See Table 1 below for a breakdown of the numbers of students graduating during the past 9 years.

We are in the second year of this plan. To date, no new hires are committed or in progress, institute funding remains tight, and federal research funding remains constrained with additional uncertainty since the 2016 elections. We are pleased that one replacement hire is in progress. At current staffing levels and in the current funding environment, it will be a challenge to maintain 25 graduate students in the program, let alone grow to our 30 target.

2 Teaching and the Curriculum

In 2012, the Physics Department updated and changed the graduate curriculum to concentrate on a core of classes students in all disciplines take, with further specializations in the various disciplines (atmospheric, astrophysics or mathematical physics) taking specific classes as listed in the catalog. Two courses were specifically added to the curriculum to address perceived weaknesses in the graduate population. These include a year-long communications course, done in cooperation with a 1 credit, 2 semester research project previously called Graduate Lab; and a mathematical methods of Physics course, in which all the major math concepts needed to be successful in graduate level Physics courses are covered the first semester for a new graduate student.

In 2017, Professor Sessions discovered that the communications course became a funding source. Several of her students wrote a "practice grant" to NASA spacegrant, and were funding at the $10,000 a year level as a result.

While the department has traditionally supported many M.S. degrees, it is not the main focus of our graduate program. M.S. students may pursue a general M.S. in Physics or an M.S. with a specialization in instrumentation. All graduate students must pass a preliminary examination on

undergraduate Physics curriculum at the 40% (M.S.) or 60% (Ph.D.) level in a specified amount of time (depending on what degree they had when entering the program). The examination format was changed a few years ago because we had student reports that suggested the exam was testing raw speed and stress-tolerance in addition to physics knowledge. To emphasize careful thought and an accurate assessment of physics knowledge, we made three changes. We replaced four exams of five questions each with three exams of six questions each. We increased the time per exam from 2.5 to 4 hours. Finally, rather than giving two exams in a day (on subsequent days), we spread the three exams out over a one week period. We hope that these changes to the curriculum and preliminary examination will speed students toward finishing their coursework, pursuing meaningful research and graduating in a more timely fashion.

Finally, the department hoped to encourage more of our most accomplished B.S. students to get M.S. degrees as well, and as such introduced a 4/5 year joint B.S./M.S. program 26 months ago. Our first student is about to graduate from this program, and we expect to add perhaps 2-3 more each year. The program was intended to engage some of our brightest undergraduates to pursue research early, leaving them better placed for a Ph.D. after leaving NMT. It should also allow us to generate more graduate degrees at the M.S. level without inreasing the TA budget as we are not allowed to support B.S./M.S. students until their graduate (5th) year on an RA or TA.

TABLE 1: GRADUATIONS FROM NMT PHYSICS

Year	B.S. (gen,atm,ast,other)	M.S. (terminal)	Ph.D. (atm,ast,other)
2016	12(6,0,5,1)	1(1)*	4(3*,1,0)
2015	17(12,0,4,1)	3(2)	4(2,2,0)*
2014	12(5,3,3,1)	3(2)*	5(2,3,0) *
2013	6(5,1,0,0)	5(5)*,*	1(1,0,0)
2012	9(7,0,2,0)	1(0)	2(2,0,0)*
2011	7(4,0,3,0)	2(2)	3(1,2,0)
2010	17(10,2,5,0)	1(1)	1(0,1,0)
2009	13(6,3,4,0)	7(6)	2(1,0,1)*
2008	5(3,0,1,1)	2(1)	1(0,1,0)
2007	20(12,1,6,1)	4(4)	2(1,1,0)

Total graduations per year (with a breakdown by area in parentheses). A * indicates a degree with a strong instrumentation focus. Currently these degrees are either listed as M.S. (in instrumentation) or Ph.D. in Physics or a concentration area.

Undergraduate growth will mainly be accomplished by continued recruitment activities during targeted visits of students to the campus, and through outreach activities to middle and high schools around the State. Our department is active in nearly every campus research visit, has an active Physics Club which regularly provides demos and does outreach activities to local schools, has several faculty and graduate students who support science fairs and give local school talks, and we additionally make use of the recruiting materials/information sent out by NMT Admissions and provided to the departments. In 2017, we updated our recruiting brochure with Admissions.

Continued growth in the Physics department undergraduate numbers will depend heavily on high-school level preparation of students prior to coming to NMT. As such, a few faculty in the department are active in the MST program, either teaching classes or supervising MST degrees as additional load or during summer sessions. This effort is very valuable for NM and the department will continue to support training of math and science teachers as an additive and crucial focus area for teacher training in NM. Additionally, one member of the department (Sessions) has recently

taken on the position of NMT Liaison to the schools in the city of Socorro. This may encourage local growth for the department, but also help to develop strategies for future recruitment activities.

One of the exciting growth areas we have seen in the past few years for recruiting undergraduates to Physics comes in the form of the Living Learning Communities (LLCs). Two LLCs (Sustainability Sessions/Minschwaner; Radio Astronomy Hofner) have been offered a few times each and have been very popular at NMT, attracting several new majors to the department. If appropriate resources and support are made available (specifically another faculty line and TA support within the LLC classes), faculty are interested in continuing to offer 1 or 2 LLCs per year. As a department we additionally support the LLCs by allowing the LLC + lab courses to count as one of the breadth concentrations in science which the department has maintained for its own majors despite NMT voting to eliminate this requirement campus-wide recently.

In 2016, we passed changes to our undergraduate curriculum after a year-long self- study into our program. The focus of these changes was to create a strong, three-part foundation in theoretical, computational and experimental techniques required for a modern understanding of physics. These changes occurred principally during the Sophomore year and included two main foci: a) extending a one-semester Computational Physics course to a two-semester course using Matlab, Python, and more advanced Physics concepts, by eliminating a course called Vibrations and Waves plus its lab, and b) subsuming labs previously offered in the Vibrations and Waves lab into the Comprehensive Physics two- semester lab sequence normally taken by Sophomores while also raising the level and content of the labs for this course. These changes are intended to strengthen our undergraduates capabilities in modeling, computer programming, and the use of modern equipment in the laboratory.

3 Research and New Initiatives

Funding pressure in our disciplines remains very high. For the astronomers in the department, most research funding comes from either NSF or NASA. Some of this funding is attained by submitting competitive telescopes proposals (e.g. Chandra, Hubble, Spitzer all NASA operated facilities) which bring with them small amounts of funding for data reduction and publication. Other in kind contributions occur when faculty or their graduate students are able to get competitive telescope observing time which usually brings with it no funding, but would be impossible to pay for outright. For instance, one paid night on the 4.2m Discovery Channel Telescope costs about $13K, and a night of Keck Interferometer time (when it was operational) was worth $100K. Additionally, graduate students working primarily with the EVLA or ALMA facilities are able to receive 1-2 years of competitive pre-graduate support through NRAOs Reber Fellowship program. We have had as many as 4 graduate students supported by this program at any one time in the past few years. NSFs funding rate in astronomy is running sub 15%, with NASAs only a tiny bit higher. Other Federal agencies do not have regular calls in areas the astrophysics faculty specializes in. There are typically only 1 or 2 major calls per year that the faculty in astronomy might put in a competitive proposal for with either of these agencies. Despite these pressures, nearly all astronomy faculty in the department have had a major grant during the past 5 years.

In atmospheric physics the situation is a little bit more promising. Our department faculty have recently secured funding from NSF, DARPA, NASA (e.g. via JPL), and private foundations as well as student support through the Space Grant and NASA EPSCoR. While still quite competitive, the global interest in climate issues and the smaller number of universities participating in these activities, has allowed us to remain competitive. Many opportunities in these areas are not offered

through structured calls, which allows faculty to submit proposals in an at will type of scenario as they develop new initiatives. This has the added benefit that these proposals are less constrained by proposal calls which often have very specific requirements for eligibility. Nearly all atmospheric faculty have had a major grant in the past 3 years.

Faculty discussed how productive we felt we could be in terms of supporting and directing graduate students during our department retreat on Jan 15, 2016. Most faculty felt they were most effective when they had two or three graduate students working with them, usually on similar or closely-related topics. Faculty felt they could reasonably support 1-2 graduate students with research funding at any given time, with perhaps a more junior graduate student coming on board as a TA. While this is ideal, the realities of funding often force senior graduate students to return to TAs near the end of their careers, which the faculty agree is non-optimal. Since the earlier retreat, the chair has observed that on average faculty are able to support about one doctoral or MS student at a time on external funds.

Finally, we note that in the past 4 years, 3 theses and 3 dissertations have been completed in the department with a strong instrumentation component (either building and testing a new instrument or major instrument component as part of a larger project). It is for this reason that the Physics Department believes the area of greatest potential growth for graduate students and new faculty is associated with instrumentation. We presently offer an M.S. in Instrumentation, which is a terminal degree for most of those students (i.e. they do not stay at NMT after getting this degree); we are in the process of developing and adding a Ph.D. concentration in Instrumentation. Additionally, an instrumentation focus in Physics dovetails nicely with the engineering focus at NMT, the new biomedical technology degrees being introduced at NMT, and may help support students in other departments at NMT who wish to have an instrumentation focus but cannot get a Ph.D. from other departments because they are unable to offer Ph.D. level degrees. Two main areas where the Physics Department would like to develop and deploy more instrumentation focus are associated with Langmuir Laboratory and the MRO observatory. A discussion of the state of those facilities and potential contributions in each area is presented briefly below. Additionally, we discuss more of our research synergy with NRAO. Our goal is to roll out the graduate instrumentation concentration by Fall of 2017.

4 Langmuir Laboratory

Langmuir Laboratory, named in honor of Nobel Laureate Irving Langmuir and established in 1963 by E. J. Workman, includes several facilities on the top of Magdalena Ridge/South Baldy to support atmospheric physics research, in particular focusing on atmospheric electricity. It is one of only 2 such programs in the United States, and one of only 3-4 similar programs throughout the world. The Ridge facilities include: two 20 foot diameter underground "kivas" supporting rocket-triggered lightning and lightning rod studies, a 3000 square foot, six-story high balloon hangar from which to launch custom instrumentation into storms, and 19,000 square feet of flexible laboratory space in two buildings 1.5 mile south of South Baldy Peak. As instruments have gotten more automated, Langmuir has moved to a network focused mode of operation in which the entire mountain and environs become the laboratory. Gigabit optical fiber (protected from EMP's caused by lightning) covers the mountain allowing a network of instruments to be simultaneously focused on storms. These currently include field mills, slow-antennae, the worlds best 28- station lightning mapping array, high-speed video cameras, and a new technology interferometer with 10 times the data rate of the lightning mapping array (LMA). This formidable array of instrumentation and capabilities

makes Langmuir hard to beat, but it does not maintain itself, nor does it write papers making sense of all the data it can generate. In order to stay competitive, we need more faculty driving the effort forward. Presently two regular faculty and two retired faculty in the Physics department (and one additional regular and two retired faculty in Electrical Engineering department) participate actively in the use of the facilities. There are staff associated with the operation and upkeep of the facilities as well, usually paid directly from grant work or as part of a small endowment. During the most productive period of use of the facilities, there were 4-5 regular faculty (between Physics and EE) and their associated graduate students making regular use of the facilities. In the recent past, grants from DARPA and programs including a group from Europe attempting to trigger lightning using laser ionization of the air have required large and sustained effort associated with use of the facilities. In order to deploy new instrumentation and make full use of the facilities, at least one more faculty member should be added to the Physics department, and ideally the EE department as well as there is clear advantage in the collaboration on atmospheric electricity.

In 2017, there is an active search for a new faculty member who might be a Langmuir user. This person is replacing retired Professor David Raymond, it is not actually a new tenure-stream line. Thus we strengthen Langmuir, in the near term, while Dr. Raymond is still active and supporting our modeling and climate focus. [1]

5 Magdalena Ridge Observatory (MRO)

The MRO (started in 2000, with an Environmental Impact Statement (EIS) use permit issued in 2003) includes two facilities, an operational 2.4m stand-alone telescope (at the location of a prior telescope facility) and a 10-element optical interferometer (MROI) (located in the saddle between the MRO 2.4m and the main Langmuir facility). To date, over $65M has been spent on this MRO facility, with a large portion of the funding derived via NRL as a result of directed earmarks from the NM Congressional Staff. The 2.4m telescope has been in operation since late 2007, while first fringes for the interferometer is expected in late 2018/early 2019. After four years without external funding the MROI went into a dormant period. However, $25M has recently been established through a Cooperative Agreement with AFRL to bring the MROI facility to three operational elements by 2020. An additional $55-65M will be required to complete the final 7 elements (and associated beam trains) of the MROI. The funding will likely come from a number of sources including State and Federal government agencies, philanthropy and grant applications.

The MRO 2.4m telescope is presently both underutilized in terms of total operational nights on the sky (120 nights per year are advertised as being useable), and also in terms productivity in the refereed literature (see appendix A for an analysis). Faculty in the Physics Department, principally the 6 astronomers (though there have been discussions about atmospheric physics studies that could be conducted using the 2.4m as well), all undertake programs which would benefit from access to and use of the 2.4m telescope, especially if it were properly outfitted with a wider variety of instrumentation than just an optical CCD currently available. All of the facultys scientific ideas could be used as the basis to apply for funding that support research and student researchers and generate more overhead at NMT. This type of work would additionally help develop more refereed publications for the Physics Department and the MRO 2.4m and, in time, theses and dissertations. Additionally, name recognition of the facility would aid with recruiting students and additional

[1] It should further be noted that Dr. Raymond earned the Jules Charney award, the second highest award given by the American Meteorological Society, for a lifetime of contributions to the theory and modeling of convection.

funding to the MRO and NMT communities. The current operational model for the facility is far from ideal. There is no published telescope schedule, no Time Allocation Committee (TAC), and no mechanism on the website or elsewhere describing a method by which researchers (either inside or outside NMT) can apply for observing time. Additionally, there is no (publicized) mechanism at NMT to allow faculty or staff research using the 2.4m to support grant writing activities (e.g. via seed funding), and the current charge rate structure (nearly $5K/night with overhead) makes the facility unattractive or unreasonably expensive for most faculty/students to consider for modest start-up projects. Because the facility is officially under control of the Regents of NM Tech, it is the opinion of the Physics faculty that the MRO 2.4m telescope needs to be operated in a more transparent and easily accessible way (both monetarily and physically in terms of access and scheduling) so that the entire NM Tech community can participate in its use; otherwise the telescope should not be advertised as a recruitment tool for research at NMT.

If a new access policy is implemented at the MRO 2.4m which allows faculty and students within NMT (all departments, not just Physics) to make use of the facility, there are several places the Physics Department faculty are willing to explore contributing to the facility operations model to increase its use within the NMT community. These include development of: a) a time allocation committee (TAC), b) a facility-users/instrumentation committee, c) a training program for undergraduate and graduate students to operate the facility for both fundamental training in telescope operations and to enable more observation nights, d) explicit grants and refereed papers with NMT students and faculty using the facility to support their research. Some of these initiatives (e.g., specific research assistantships for graduate students to operate and use the facility) could serve to support both the facility operations model and the Physics Departments needs in terms of growing and sustaining a nationally recognized research portfolio and a larger student body.

While not yet operational scientifically, the MRO Interferometer (MROI) has employed more than 50 students at the undergraduate and graduate level over the past 15 years of its development. An M.S. thesis and a Ph.D. dissertation through the department of Physics have been completed in the last few years, directly contributing to the instrument design goals of the interferometer. Additionally, 4 refereed articles, 53 SPIE (society of optical engineering) design/study papers on subsystems of the interferometer, and a workshop/conference proceedings book with over 40 articles on the science that could be realized using MROI have been published since 2000. Continued utilization of the facility, including building more instrumentation and software for the interferometer subsystems, developing detailed science cases, writing grants to fund new instruments and first-light science, and eventually supporting students interested in pursuing interferometric science topics for their research, will require adding additional faculty over the next 5 years to bring the Physics Department complement of researchers using MROI to a critical mass.

6 National Radio Astronomy Observatory (NRAO)

NRAO, while not technically an NMT facility, is integral to the astronomical efforts in the Physics Department. Five of the six astrophysics faculty in the department regularly use the NRAO facilities (the EVLA and ALMA principally) for the basis of their observational programs. Most astrophysics faculty have collaborators at NRAO and over the past 10 years more than 15 researchers at NRAO have been adjunct faculty (serving on graduate committees or supervising research programs) for students in the department. The co- location of NRAO with NMT is clearly a draw for students interested in pursuing graduate work in radio astrophysics at NMT. NRAO hosts local workshops and conferences several times per year, the National Jansky Lecture in Radio Astronomy, and a

Friday seminar series, all of which are often free to NMT faculty and students to attend. And finally, NRAO has periodically offered pre-doctoral fellowships (recently renamed Reber Fellowships) which help support astrophysics graduate students using NRAO facilities during their last 1- 2 years of Ph.D. work. We have a healthy and vibrant collaboration with NRAO which we wish to maintain and nurture into the future.

7 New Revenue Streams

Our faculty are eminently aware of the increasingly competitive Federal funding environment. Our approach to address this challenge is two-fold:

Maintain (and enhance) our nationally competitive areas (astrophysics and atmospheric physics).

Find new ways to monetize our current efforts – teaching Certain graduate courses we offer (e.g. atmospheric convection, physics of lightning, radio astronomy) are unique or nearly so. We believe there is demand for distance education or professional development courses in these areas at a non-commodity funding level. If the department could somehow benefit from the extra effort to develop and teach these courses (additional base budget, graders, TAs ...etc.) or if the providers of these courses could be compensated at a per student level, then we might be able to put substantial effort into this and benefit the university.

In 2017, there was a discussion with the engineering departments to start a "professional development school" within Tech that would offer 4-day short courses at a cost of roughly $2500 per seat. We recommend this.

Find new ways to monitize current efforts – instrumentation Our instrumentation focus represents a tangible alternative funding source. Historically, the LMA group brought in at least $1M yearly of funding directly tied to instrumentation, and NESSI was built using a combination of external and internal funding to develop a $3M instrument for MRO. The current faculty associated with Langmuir Laboratory are approached for instrumentation projects with some regularity. Making it easier (or possible) for faculty members to sell scientific instrumentation through the University might lead to interesting new revenue concepts in terms of intellectual property, patentable designs and new collaborations via SBIRs, and other initiatives not tied directly to Federal sources.

8 Faculty Hiring Plan

We projected in 2016 that one to two faculty would retire by 2021. One, Dr. Raymond, already retired. There is also a "risk" of junior faculty getting a better offer or having some other personal reason to leave New Mexico Tech. We believe that our research productivity (we are regularly one of the top grossing departments on campus) and service teaching loads support the assertion that faculty who leave or retire should be immediately replaced to maintain our current concentrations and expertise. We are grateful that last year's plan was read and that there is an active search to replace the retired faculty member. There is still no growth, however.

We propose hiring up to five additional faculty in this five year plan, depending upon university needs and where funding can be secured from, bringing us to 16 (FTE) tenure- track faculty (two

of whom might hold joint appointments with other departments). The list below is not prioritized. Allocation and a brief justification for each line is as follows:

Tenure line 12: Teaching Focused Faculty. – This would be a tenure line with a focus on teaching. We could emulate many other successful programs and hire someone out of a Physics Education Research group. We assume that NMT will be growing enrollment at 4% a year over next 5 years. The additional tenure line is appropriate under even a modest growth assumption. The unsolved problem of Physics 109, support of the LLC courses, and anticipated growth in the Physics 121 and 122 numbers are ideally handled with the help of a physics education researcher. Our weakest NMT students need our strongest teachers, thus there is some urgency for this hire.

Tenure line 13: Langmuir Lab Faculty (shared) – Langmuir Lab has historically had 3-4 active faculty supporting its programs and in this way has reached an incredible synergy that has made it one of only two forefront lightning research groups in the US (and arguably the premier group). At present, there are only two active faculty and several active retirees. The energy of these retirees will fade, most likely over the next 5-10 years. We need to bring on new faculty to begin ramping the Langmuir program back up and creating new synergies within the department. Langmuir has always focused on experimental physics and instrumentation. Both of these support Tech's engineering missions (and could provide projects and employment for engineers as well). Instrumentation sales are also a possible alternative funding source for NM Tech. We are open to having this tenure line be joint with Electrical Engineering. We have had discussions with the EE Chair, Dr. El-Osery, about this possibility.

Tenure line 14: MRO Interferometer Faculty – If we assume that the MRO Interferometer will become a functional facility in the next five years capable of producing scientific papers, then it needs more support, not least because the entire scientific program of this major new project at Tech now rides on the back of a single faculty member in Physics. This tenure line would strengthen the astrophysics and potentially the instrumentation graduate programs, and additionally help tremendously in garnering more funding for the facility.

Tenure line 15: MRO 2.4m Telescope Faculty – This line could be thought of as a re- allocation or re-alignment of existing efforts at NMT. The MRO 2.4m is presently not well-integrated into the Physics or any other academic department on campus. The Physics Department is a natural home for the observatory, but inappropriate staffing and historical issues have made this part of MRO an orphan within NMT. We propose re-directing MRO support efforts under a new Physics tenure line which would establish a coherent plan for observatory operations, help garner funding and support for the facility, and integrate the observatory within the NMT community. This is a typical operations model for most university observatories a faculty member with allegiance to the University and Regents acts on their behalf to see that the observatorys operations model meets the needs of the faculty and students at the University while a professional management staff oversees daily operations of the facility. (The management function could continue to be filled in some fashion by present observatory staff.) The expectation would be that the telescope would serve the entire NMT community.

Tenure line 16: Biophysical Instrumentation Faculty (shared) – The Department met and carefully evaluated its strengths in atmospheric and astrophysics to consider whether we should add a "third area" of concentration. We want to continue to maintain our strengths in instrumentation, while capitalizing on the competitive research environment in the U.S., which is clearly moving strongly towards modern instrumentation and Biotechnology. For these reasons, Biotechnology/Biophysics is presented as an additional tenure line and growth

into a potential third area. For the same reason that our existing strengths need critical mass, so too would Biophysics. It is clear that one faculty member in isolation would not succeed, or that we could attract someone of quality to our department at this initial juncture; this position is thus assumed to be interdisciplinary. We would expect a joint hire with Biology, Chemistry or Chemical Engineering would be the most natural home for a position like this. We believe the Physics Department could support this hire with instrumentation collaborations, the hire would strengthen the programs in other departments with a custom instrumentation component, the hire could broaden our instrumentation graduate program, naturally attracting industry/medical funding (e.g. NIH or collaborations with large research hospitals), and finally, that we could add undergraduate and graduate coursework in this rapidly growing area of science and technology which is also a new focus at NMT.

9 Space Considerations

Compared to other departments, our department is in a good situation, spacewise, however if our hiring plan were fully executed we do not have space identified. There are some spaces held by productive emereti which will be recovered for newer hires as they are needed. Also, we have a computing cluster. If it could be centralized, then it would free up the space for instrumentation (or other) new faculty. MRO has office space in the ROB and it would make sense to move a nucleus of MRO researchers (graduate students and postdocs) to that space, thus opening other offices in Workman. A teaching-focused faculty member likely will not need explicit laboratory space. Our proposed Biophysicist hire is challenging, and requires more consideration, but we expect other departments would be motivated to find a new person a home as well if there were a joint hire. These discussions could be folded in to space plans for new buildings on campus, which may accommodate hires in Engineering or Biology/Biomedical Sciences.

Quite separately, growth of the graduate numbers can be accommodated with existing space in offices and labs on the 2nd and 3rd floors of Workman. We have had as many as 30 graduate students in the department in the past 10 years, and so believe we can accommodate this many students again. This is principally accomplished through group offices for new graduate students, and placing student desks in research labs or placing students at MRO and NRAO (for the more senior students fully engaged in research).

One area where space is difficult will be growth of our teaching labs. At present, Physics 121 and 122 labs in Workman are built for only 4 benches of 4 students each. If there is continued growth of the incoming student population, accommodations including other times of day (mornings) and weekends may need to be considered if larger spaces cannot be found or present spaces cannot be renovated. One solution may exist in the form of a new Engineering building on campus, which could free up some lab spaces in Workman on the 1st floor allowing for larger lab sections (assuming appropriate renovations and new equipment).

10 Focus Areas for Needs and Further Growth

A perennial and increasingly urgent problem is that our department's undergraduate teaching mission is inadequately funded. Consistent with the "planned growth" plank of our new Strategic Plan, the Physics department needs a realistic base budget and 3 more TA lines. At present 12 TA lines are funded, but we offer 14 TAs worth of recitations and labs normally (and often more

during Fall semesters). With the changes to the departments Sophomore sequence, we will need one additional TA, bringing the present need to 15 TAs. Development of new labs for the Sophomore sequence and replacement of aging equipment requires that we stop augmenting an inadequate TA budget with the departments lab fees. Further growth at the university will require more TA lines for the Freshmen labs and potentially new lab space and more lab equipment to offer labs to a growing student body. Additionally, in order for faculty to be more productive in terms of supervising student research and writing proposals, more funding is needed for department graders. We can presently offer only 4 or 5 classes with graders in any given semester (usually just the Freshmen classes), while the request for graders is 3 times this. The need for graders will only grow if we increase our undergraduate class sizes in the department, so an augmentation of at least $30K is required for the undergraduate student worker budgets. Finally, the Departments travel budget is inadequate to bring in outside speakers or properly support our own students and faculty with seed funding when they wish to attend a workshop or conference for professional development. This directly impacts our abilities in terms of outreach and developing professional contacts in the community. Our present travel budget is $1300/year. A budget closer to $10K/year would allow us to realistically pursue more of the types of activities needed to reach our departments potential.

Continuing on the inadequate funding theme, the department has offered Physics 109 for the past six years. We have been able to do this because Dr. Loren Jacobson, a retired metallurgist from Los Alamos National Labs, has become so enamored of teaching that he is willing to give intense attention to 30 undergraduates a semester for a few thousand dollars. Dr. Jacobson's health is fragile of late, and it is unclear how long he can sustain supporting NMT in this way. This course, however, has been identified as a key course for incoming, ill-prepared students who wish to get up to speed to pursue a STEM degree and has been shown to be effective in increasing the success rate for at-risk students at NMT. A long-term solution to this issue and the continued admission of under-prepared students needs to be achieved and we wish to work with the Administration to find a sustainable, long-term solution.

The Department agreed that we would like to continue to concentrate on our endowments and outreach activities as we have two potentially major gifts that could be augmented to eventually support endowed Chairs and/or graduate Fellowships. These are associated with the Wilkening and Millar endowments/families. The Department would like assistance and a targeted capital campaign to help grow these endowments to a level where they could sustain either a faculty member or a graduate student as per the endowments wishes. However, the mechanism for accomplishing this and how much money is required to sustain this are not presently clear at NMT. Help from the Administration will be required to have success in this area.

Similarly, the Department is interested in establishing an Advisory Board of department alumni, industry and community leaders, and researchers from the national labs to help us maintain a strong program and develop new initiatives. We also want to use this Board to create a better pipeline for our graduates and to provide additional cooperative study opportunities. We have some formative ideas on how this might be accomplished, but would need support of the NMT Administration to make this effort effective. We assume there will be funding needs associated with establishing a Board.

Other initiatives we will continue to work on include graduate recruitment through the funding provided by the graduate office. We encourage other business units at NMT to establish seed-funding similar to that provided by the graduate office as faculty can often get more bang for the buck out of one extra days stay during a visit with collaborators, etc. More specifically, targeted funds from the Admissions/Outreach, and Development offices could augment faculty visits to other

institutions so that faculty could accomplish a quintuple mission of NMT recruiting in general, NMT Physics recruiting, NMT reputation building, Tech alumni networking, and a stronger national presence for NMT.

11 Institute-wide Issues with Impact to the Physics Department

11.1 Geophysical Research Center

Physics and Earth Sciences, our two strongest research departments at NMT, have benefitted from the Geophysical Research Center. This "special project" has channeled roughly an additional $800,000 a year to Tech to support six full time positions which support a dozen faculty half-time in a few departments. As the State of New Mexico continually pounds on "special projects", GRC is habitually at risk. We want to highlight both the value and vulnerability of GRC to President Wells and our new NMT Administration. It represents an additional funding stream to NMT research, and it has been very effective. Untended, it also represents an additional risk as it effectively puts a dozen productive tenured faculty on "soft money". We recognize that the Administration is looking into long-term solutions to the GRC funding issue; whatever solution is arrived at will have major impact for the Physics Department and needs department participation.

11.2 Alternative Licensure Program

Our discussion of improved outreach and recruiting would be incomplete if we did not mention the former alternative licensure program (ALP), which allowed undergraduates to also secure teaching certification as part of their coursework at NMT. Typically we had at least one student per year who was either more interested in teaching or not prepared for the challenges of a full-time research position, but had far higher in subject competency than most high-school physics teachers. The elimination of ALP did these students a monumental disservice by making it harder for them to go into teaching careers. This also did a disservice to the general community by reducing the number of messengers we sent out into the world who could return to NMT excellent students in all our STEM disciplines. We encourage President Wells to investigate how he might resume/re-enact the alternative licensure program, and hope he can make the case that it deserves augmented funding. New Mexico Legislators are well-known to be very focused on K-12 education, sometimes to the detriment of higher education, and NMT should continue to participate in every way possible in this space because good K-12 STEM teaching benefits all of us.

12 Executive Summary

The following areas have been identified for growth and needs for the Department of Physics over the next 5 years:

Growth of graduate numbers to 28-32 Growth of undergraduate numbers to 100- 120. This will be accomplished through continued outreach and recruiting efforts and from new focus areas discussed above. Additional TA lines and research funding will be required to sustain this.

Addition of an Instrumentation Concentration at the Ph.D. level Associated with this will be more efforts working with Langmuir, MRO, NRAO and other departments (e.g. EE, Biomedical Technology).

Replacement of any retiring or departing faculty members Addition of up to 3 faculty in Physics, and 2 additional shared positions, consistent with growth areas discussed above. Growth of existing endowments to support faculty chairs and graduate student fellowships. Assistance from the Advancement office will be needed.

Development of an advisory board for the department This would be composed of alumni and leaders from industry and national labs. Assistance from the Administration will be needed.

Full support of the present state of the departments teaching mission This will require 3 more graduate TA lines and an additional $38.7K, primarily for student salaries and travel. Growth in undergraduate numbers in the department or at the university in general will require augmented funding and more TA lines.