CNS Strategic Planning 2010

DEPARTMENT OF PHYSICS AND ASTRONOMY

1. Unit Strategic Plans

A. Evaluate the prior (2005) strategic goals, highlighting progress that was made toward each. Discuss changes and modifications, if any, made to your unit's goals in the interim, describing the reason(s) for the change.

The 1998/9 strategic plan for the Department of Physics and Astronomy (PA) contained the following strategic goals: (goals listed in angular brackets, followed by a brief evaluation)

- [*Move into and utilization of the new BPS building*] - This was accomplished extremely successfully. Our research and teaching facilities are now among the best in the nation. Many facilities in the new building initially were not performing to specifications or needed to be modified. But with the help from CNS and the central MSU administration all changes were accomplished.
- [*A successful applied physics degree program*] – In 1998 the external funding constraints were such that we anticipated a shift of federal funding from basic to applied programs. This shift did not materialize, and so it was prudent to shelve plans for an applied physics degree program.
- [*A successful, unique joint Ph.D. program*] – A joint Ph.D. program in Biophysics was established in collaboration with Biochemistry. Two new faculty (Wedemeyer, Lapidus) were hired, and we anticipate future hires in this area as well. There seems to be a moderately strong demand from graduate students to apply to this new joint Ph.D. program.
- [*A successful search for a group in Condensed Matter Physics*] – Our 1998/9 plan envisioned the hiring of an entire group consisting of a senior faculty and two or more junior faculty, with a new research direction. Through repeated senior offers we learned that it is very difficult to attract a senior and well-established faculty member away from her/his home institution. The search for the Cowen Chair thus continues. On the other hand, we were very successful in hiring absolutely first-rate junior faculty (Piermarocchi, Ruan, Wedemeyer, Lapidus).
- [*First-class nuclear physics program with an active Nuclear/Particle Astrophysics Section*] – Our nuclear physics program is now rated number two (behind MIT) in the country. The coupled cyclotron project was brought to a successful conclusion. A very strong push towards the next accelerator project, RIA, continues. Just as envisioned in the 1998/9 plan, we have been successful in establishing a strong presence in nuclear astrophysics, most notably with the award of the Joint Institute for Nuclear Astrophysics (Schatz, Beers, co-PI, with Notre Dame and Chicago).
- [*Promoting an active academic accelerator physics program*] – Our efforts in theoretical accelerator physics (Berz) have been very successful, in particular

in the area of virtual university graduate accelerator physics courses. In experimental accelerator physics we also produce many Ph.D.s, but these students are mainly supervised by adjunct faculty with appointments at the NSCL. We have had to focus our limited faculty lines to ensure that the NSCL's large NSF grant receives renewal and to position ourselves in the competition for RIA. This left little freedom to build up an active experimental academic accelerator group in the Department of Physics and Astronomy, and currently only one faculty member (Schriber, joint with NSCL) is engaged in this effort.

- [*Engagement in a new High Energy Physics initiative*] – We are still strongly engaged at Fermilab and have hired one additional junior experimental faculty (Tollefson) to ensure our continued presence. Our experimental effort at CERN is steadily increasing. These two efforts are central to our continuing federal grants and need to be kept strong. A non-accelerator based program, as envisioned in the 1998/9 plan, has not materialized yet. At present, one faculty member (Linnemann) participates in the Milagro cosmic gamma ray experiment. An increased presence in this area will only be indicated if present external grant support can be extended significantly. In high energy theory we have improved our position tremendously with the hiring of two new senior faculty (Simmons, Chivukula).
- [Making use of the SOAR telescope with the MSU IR imager] – SOAR construction is completed, after some delays. These delays were caused by factors out of our control, mainly by external contractors (Goodrich). At present it is anticipated that SOAR and the imager will be fully operational for scientific data runs at the end of this calendar year. Several outstanding new faculty (Zepf, Donahue, Voit, E. Brown) were hired, partially in anticipation of the new science opportunities that this new research instrument will afford our astronomy program.
- [*Strengthening the diversity of our PA faculty*] - Women are one of the most underrepresented minorities in physics. Early in 2000 we had zero female faculty members. Now we have four tenure track female faculty (Simmons, Donahue, Tollefson, Lapidus), plus one joint NSCL/PA faculty (Nunes), and two research faculty (Ghosh, Makino). While there is always room for improvement, our efforts to increase diversity clearly have been successful.

Overall, PA has been very successful in implementing the 1998/9 plan. The department has improved its standing and is now ranked among the top 10 of all physics and astronomy departments in the nation in terms of external grant funding and citation rating.

B. Provide an overview of the status of your unit today, categorizing your comments according to its teaching, research, and service missions. Highlight challenges in each area and describe how these challenges are being addressed to enable your unit to continue to advance your missions and goals as well as those of the College and the University.

Personnel

The Department of Physics and Astronomy currently employs 59 faculty members. The department consists of 4 major research groups, astronomy (AST), condensed matter physics (CMP), high energy physics (HEP), and nuclear physics (NUC). For the latter three groups, we have separated the totals further into experimental (E) and theoretical (T) physics. For the purpose of the following statistical compilations, we have made the following assignments of individual research efforts in other subfields: Biophysics (Wedemeyer: CMPT, Lapidus: CMPE), psychoacoustics (Hartman: CMPT), atomic physics (Bollen: NUCE), and accelerator theory (Berz: HEPT). All tenure-track faculty, with the exception of Wedemeyer (40%) have their tenure home in PA.

Table 1 lists the distribution of the tenure-track PA faculty members by research interest group and by age bracket.

Age	AST	CMPE	CMPT	HEPE	HEPT	NUCE	NUCT	Total
30-35	1	0	0	0	0	0	0	**1**
35-40	0	3	1	1	0	2	0	**7**
40-45	3	1	1	0	3	1	0	**9**
45-50	1	1	1	0	2	3	2	**10**
50-55	1	0	2	2	0	0	1	**6**
55-60	1	0	1	3	1	3	1	**10**
60-65	1	1	0	1	1	0	0	**4**
65-70	0	2	1	1	2	1	1	**8**
>70	1	1	1	0	0	1	0	**4**
	9	**9**	**8**	**8**	**9**	**11**	**5**	**59**

As one can see from this table, PA currently enjoys a very healthy and fairly flat age distribution, thanks to a vigorous program of renewal and faculty hiring during the last four years. During this time span, PA hired 12 new tenure track faculty members (Zepf, Tollefson, Piermarocchi, Wedemeyer [with BioChem], Starosta, Donahue, Voit, Chivukula, Simmons [with LBS], Brown, Lapidus, Ruan, in chronological order). In addition, we hired 4 jointly appointed faculty members (Zegers, Nunes, Schriber, Duguet) who are funded by the NSCL. Only 16 faculty members, less than 1/3, are currently above the age of 60. Of the totals listed above, three faculty members have announced their retirements (Bass and Pollack in 2005, and Stein in 2007), and two others have expressed interest in retirement in the near future.

The department (including the planetarium but excluding the NSCL) currently employs 7 secretaries, 2 administrative assistants, 4 planetarium staff, 3 teaching support staff, 2 computer support staff, 3 machine shop staff, and 8 research support staff (5 of whom are paid from grant or IDC funds), for a total of 29 FTEs. Due to the budget cut in recent years, we were forced to eliminate 8 support staff positions. This has put very considerable strain on all aspects of operating the department. In order for PA to remain competitive, it is absolutely essential that some of the funds that were cut out of the departmental budget are restored.

Research

The research of all theorists in CMPT and HEPT is carried out in the BPS building, and the NUCT group is split between BPS and the NSCL. Almost all research of NUCE is carried out at the NSCL on MSU's campus, with the notable exception of University Distinguished Professor Westfall, who has a very active program at the Relativistic Heavy Ion Collider at Brookhaven National Lab. HEPE research is mainly conducted at Fermilab in Batavia, IL, with an increasingly strong component at CERN in Geneva, Switzerland. CMPE's research predominantly utilizes the state-of-the-art facilities in the BPS basement. But individual faculty members, most notably Prof. Billinge, also use larger national user facilities, such as the Argonne Advanced Light Source or the future Oak Ridge Spallation Neutron Source. The research of the astronomy group is centered on the now operational SOAR telescope in Chile, which can be operated remotely from within our BPS building.

PA has a very strong external funding record. In Table 2 we list the total extramural research grant funds (in units of thousand dollars) for each year, 1999-2004.

Year	AST	CMPE	CMPT	HEPE	HEPT	NUCE	NUCT	Total
1999	430	1,313	627	1,887	449	17,423	428	**22,557**
2000	475	1,301	789	1,800	582	16,068	612	**21,627**
2001	723	1,231	779	1,482	594	13,921	605	**19,335**
2002	922	1,310	893	1,353	623	15,376	605	**21,082**
2003	1,045	1,419	1,005	1,799	825	18,098	574	**24,765**
2004	1,472	1,981	845	2,366	904	18,005	541	**26,114**

It is evident from this table that PA continues to have great external funding success, with grant totals consistently in the annual range between $19 million and $26 million. It is particularly gratifying to note that the external funding of the AST group has more than tripled during the last 6 years, and that HEPT's funding has doubled during this time span. These large increases are mainly due to hiring of new faculty. The decrease of NUCE funding in 1999-2001 was due to the completion of the NSCL upgrade construction funding. The NSCL operations grant increased by 60% during the last 5 years.

Teaching

During the last six year, the number of majors in physics and astronomy has seen a very strong increase, much greater than the national average. The number of graduate students has also increased significantly and is a direct reflection of increased grant funding. Table 3 shows the numbers of undergraduate physics, astronomy, and astrophysics majors (no 2nd degrees, no LBS physics majors), and the number of graduate students enrolled by year.

Year	**Undergrad**	**Graduate**
1999	146	116
2000	127	118
2001	135	120
2002	166	132
2003	181	129
2004	224	131

The majority of the PA teaching load still derives from the teaching of introductory physics and astronomy service courses for other majors, as well as the integrative studies program, despite the strong increase in numbers of undergraduate majors and the large number of graduate students enrolled in our Ph.D. programs. In Table 4 we list the number of students who took physics or astronomy classes in each year (SS + US + FS). Listed as well are the enrollments in the physics/astronomy ISP classes and the LBS physics classes, which are taught by PA faculty. As one can see, total enrollment has increased by more than 1,000 students during the last 6 years.

Year	**AST**	**ISP**	**LBS**	**PHY**	**Total**
1999	165	2397	599	5610	**8771**
2000	185	2664	187	5964	**9000**
2001	169	2484	431	5922	**9006**
2002	191	2815	512	6130	**9648**
2003	208	2906	710	6094	**9918**
2004	170	2826	435	6433	**9864**

PA has been pushing very strongly to utilize technology in the classroom and will continue to do so in the future, through a continued strong support of LON-CAPA, through audience participation systems, and through the use of computers in our lab courses. This consumes valuable resources, but is essential to prepare our graduates for high-tech employment.

Outreach

PA's largest outreach venture is the Abrams planetarium. It is hosting some MSU classes, but mainly planetarium shows for K-12 classes and the public. The total number of annual visitors to the planetarium is listed in Table 5, together with the total number of recipients of our monthly Sky Calendar planetarium newsletter.

Year	Visitors	Sky Calendar
1999/00	26700	10321
2000/1	26300	9926
2001/2	25967	9698
2002/3	24150	10063
2003/4	28127	8720

Besides the planetarium, we host several thousands of visitors in the NSCL and at the MSU observatory each year. Further outreach activities include many K-12 summer programs, Science Olympiad, and other enrichment programs that are supported enthusiastically by PA faculty and staff. Particularly noteworthy is Science Theatre, an outreach organization founded by PA graduate students.

C. Review and revise the unit mission and goals, as may be appropriate.

The mission and goals of the Department of Physics and Astronomy are listed in the following and have not changed since the last review. They have served us well and continue to describe the essence of our programs. Thus this section does not need revision.

The mission of the Department of Physics and Astronomy is to investigate, apply, and communicate the laws of physics and astronomy, the fundamental sciences, to the benefit of the nation and all humanity.

Goals:

1. Perform innovative and fundamental research on physical systems ranging from the smallest to the largest and from the simplest to the most complex. Train postdoctoral, graduate, and undergraduate students to become leaders in physics and astronomy, cross-disciplinary research, and in industrial development.

2. Provide high quality teaching, at undergraduate and graduate levels, to physics and astronomy majors and to students in other disciplines.

3. Communicate physics and astronomy concepts, and our research results, to the broader community, and participate in cooperative projects that help industry, colleges, and schools to solve problems that they face.

To accomplish these goals, the Department must continue to attract and retain first class researchers who are eager to communicate, and able to communicate well, and to provide an environment supportive of research, teaching, and service.

D. Outline strategic plans for your unit in 2010 – include a listing of the unit's core strengths and discuss any changes in these strengths over the past five years as well as changes you would envision as you move forward.

i. **Faculty/staff** – project number of faculty replacements, emphasis areas, possible interdisciplinary connections, space and setup needs. Suggest innovative ways to contribute to or begin limiting startup costs.

The following is a list of core consensus items, in no particular order, which was developed during the Jan. 29, 2005, PA departmental planning retreat. Each statement focuses on a particular research thrust, and is followed by a short segment that addresses faculty replacement needs, space, setup costs, other investment needs, and a programmatic justification.

Maintain core strength needed for full use of SOAR and for effective AST Ph.D. and BS program.

The Astronomy Group's goal is to be a nationally recognized astronomy program and fully competitive with at least the other Big 10 astronomy departments and programs. The group has made great strides over the past five years, due in large part to their recruiting a new generation of faculty on the basis of MSU's participation in the SOAR Telescope. The group has doubled their publication and funding rates and has built a nationally competitive astronomy Ph.D. program that now feeds a steady stream of bright graduate students into the research program. MSU plays a lead role in the ***J**oint **I**nstitute for **N**uclear **A**strophysics*, and the PhD program now offers unique opportunities in this vibrant research area.

The SOAR Telescope will come online scientifically over the next year, beginning many years of access to this world-class instrument. The Astronomy Group must have the manpower to make full scientific use of SOAR and realize the full potential of MSU's investment. The group *must* also maintain the strength of the graduate and undergraduate astronomy majors programs. This is essential both to MSU's purpose as a teaching institution, and to the health of the research program. The minimum faculty level needed for this core program is eight positions.

Position ourselves for part of a larger future (inter)national astronomy collaboration.

The SOAR telescope has *already* proven its worth to our department by being the catalyst for a major progression in the scientific and academic pace of the Astronomy Group. Over the next year SOAR will come into full scientific stride. But it should not be the endpoint of MSU's participation in major observational astronomy projects. SOAR is complementary to other instruments and techniques. These include large-scale surveys from the ground and space, space-based observations at X-ray, ultraviolet and infrared wavelengths, and spectroscopy of very faint objects that require even larger ground-based telescopes. The best science programs in astronomy combine many or all of these techniques, and increased participation in major observational projects is necessary for MSU to move higher in national standing.

Leveraging our participation in SOAR by moving up to a new project involving one of these complementary techniques would give us a defining role and a guaranteed data flow over a wider range of the observational experiments upon which the Astronomy Group's science depends. This new project *should benefit the Astronomy Group as a whole*, just as SOAR does. Some possibilities include participation in a bigger telescope or active involvement in a ground-based or space-based large-scale survey. Over the next few years the Astronomy Group shall identify the best such project, after which the Department will work to convince the upper university administration that it is time to move forward.

Invest at least one faculty position each in areas of quantum control and self-assembly of nano-structures.

The Condensed Matter Physics group has core strengths in studying quantum phenomena in solids and studying growth, structure and properties of complex materials. We plan to replace retiring CMP faculty in order to refocus our research efforts into two emerging areas, coherent quantum control in solids and design and analysis of self-assembled nanophase materials and structures. Both of those areas are prime candidates for federal funding under the National Nanotechnology Initiative (NNI) and provide enhanced collaborative opportunities with chemistry, mathematics, engineering and the life sciences. We plan to generate large group proposals in both areas and will hire carefully to strengthen our research in areas strategic to these proposals.

Quantum control in solids refers to the use of photons or high-frequency electronics to manipulate coherently the charge, spin or atomic states of a solid. Examples include optical control of spin-spin coupling in semiconductors, and electronic control of charge states in a superconducting Josephson junction. Self-assembly of nanostructures refers to the process by which ultra-small systems assemble themselves under carefully controlled conditions, in contrast to the traditional "top-down" methods of microfabrication currently used in the semiconductor industry. A new program in self-assembly at MSU would complement existing strengths in the determination of nanoscale structure and in electrical transport of microfabricated systems. It also provides another link to our new program in biological physics which focuses on self-assembly and which also requires careful characterization tools at the atomic scale.

Increment bio-physics effort.
The PA department plans to expand its biological physics effort by building upon the exceptional hires it has made during the past three years. We propose that the PA Biological physics effort be focused on one area so that an effort of national prominence can be developed at MSU. The focus area we have identified is in the area of self-assembling biological macromolecules. The specific outstanding problems to be addressed are determining the structure of such assemblies, and characterizing the physical interactions governing their assembly. Self-assembling biological macromolecules include many molecules directly responsible for human, animal and plant diseases, such as viral protein coats, bacterial secretion needles, and amyloid fibrils. This science impacts a broad spectrum of health issues, including the HIV epidemic, emerging new viruses such as SARS, threats of bio-terrorism, rising bacterial drug resistance and overall aging of the population (leading to increased incidence of amyloid diseases).

The CMP group has two biological physicists already working in the focus area, Lisa Lapidus and Bill Wedemeyer. Lisa Lapidus is using optical methods to study RNA and protein folding and aggregation. Bill Wedemeyer is using computational and spectroscopic methods to study bacterial type II and type III secretion needles. An attractive next hire for PA Biological physics would be someone with expertise in molecular visualization/structure (e.g. cryo-electron microscopy or solid-state NMR methods), Ph.D.-level training in physics, and interest in developing new experimental methodologies for characterizing protein assemblies. This person would significantly broaden the skill set of the PA biological physics effort and would couple well with several other faculty in the CMP group, and with many other members of the life sciences faculty at MSU. In the longer term we anticipate further hires in biological physics, as our new hires become more established and as opportunities arise.

Maintain a diverse experimental and theoretical particle physics program centered on a vigorous collider effort.
The landscape of high-energy physics will change dramatically during the 2006-10 period. For the last thirty years the incomplete “standard model” has successfully described all particle phenomena. In the next five years the shortcomings of the standard model will be explored by proton-antiproton collider experiments ongoing at the Fermilab Tevatron, and then will be definitively probed by the experiments slated to begin in 2007 at the proton-proton CERN Large Hadron Collider (LHC). The results of these experiments will uncover new

fundamental laws of nature, and redefine the questions of particle physics for the ensuing decades. The goals of the HEP group are to fully participate in this collider program, and simultaneously to address the diverse new questions that the collider results will pose.

The MSU High-Energy Physics experimental group has strong collider efforts on the CDF and D0 experiments at the Tevatron and the ATLAS experiment being constructed for the LHC. The experimental group also has an active effort in cosmic ray physics (the Milagro experiment), and is exploring participation in a new Fermilab neutrino experiment or in a future International Linear Collider. The High-Energy Physics theory group engages in problems of direct relevance to collider physics, including topics in quantum chromodynamics, electroweak physics, and physics beyond the standard model. An additional theory effort studies the physics of particle beams, and using their methods the group has developed the world's most precise computer code for predicting and analyzing the dynamics of particle beams in accelerators. Of particular note are the links between theory and experiment, as exemplified by the group's strong role in the Coordinated Theoretical-Experimental project on QCD (CTEQ), and the wide use of the group's beam dynamics tools.

The HEP group anticipates several retirements during the coming five-year period, and will propose to replace faculty in a timely fashion to insure the group's continued ability to have impact in both experimental and theoretical particle physics. Of highest priority in experimental HEP is the hiring of two junior faculty on the ATLAS experiment and the establishment of an additional strong experimental program. The highest priority in HEP theory is the hiring of a junior faculty member with interests complementary to the existing group.

Protect technical staff essential to research groups.
Cutting-edge research in condensed matter physics (CMP) requires an increasing level of sophisticated equipment and facilities. Often the cost of acquiring, maintaining, and operating such facilities are prohibitive for a single investigator, hence there is an increasing move to shared facilities. Such facilities, in turn, require dedicated technical staff. The CMP group is fortunate to have Drs. Reza Loloee and Baokang Bi as our two technical staff members. Dr. Loloee is an expert in electron microscopy who maintains, operates, and trains graduate students in the use of several shared facilities in the basement of the BPS building, including two SQUID magnetometers, a sputtering system, a profilometer, and Electron Dispersive Spectroscopy (EDS) of impurities in solids. He is also the safety officer for the basement laboratories. Dr. Bi manages, operates, and trains students to use the Keck Microfabrication Facility and its associated Clean Room. That facility plays a crucial role in the research efforts of several faculty in the CMP group. Continued general funds support for these

two people, as well as for the mechanical and electronics shops, is essential to maintaining and expanding the research capabilities of the CMP group.

During the last two decades MSU HEP group has established a pattern of strong participation in and leadership of major experiments at the international high-energy hadron colliders. In large measure this has been due to our ability to contribute vital mechanical and electronic components to the experiments. This has been made possible by the careful nurture over three decades of outstanding electronic and mechanical design centers with ongoing departmental and university support in the form of dedicated laboratory space, technical personnel, and partial overhead return. If we are to continue to play major roles in the collider experiments, and if we are to retain our capability of reacting rapidly when new and interesting experimental challenges present themselves, then we must safeguard and strengthen these unique electronic and mechanical capabilities. Continued departmental and university support for these facilities, in particular for electronic design engineer Dan Edmunds and mechanical technician Mike Nila, is essential.

The department unanimously supports the effort to attract RIA to MSU.
The Rare Isotope Accelerator (RIA) is a nuclear physics research laboratory designed to produce thousands of isotopes that do not exist naturally on earth. The facility will make it possible to address some of the most fundamental problems in science, including the origin of the elements heavier than iron and the derivation of the properties of complex nuclear systems. The DOE/NSF Nuclear Science Advisory Committee has recommended RIA as the highest priority for major new construction. The 20-Year Science Facility Plan of the DOE recognizes RIA as the number three priority in their list of projects with the highest scientific importance.

For many years the NSCL has been a leader in rare isotope research. The completion of the Coupled Cyclotron Facility in 2001 established the NSCL as the nation’s premier rare isotope facility for the coming decade. Locating RIA at MSU will provide a logical cost-effective progression of this research. Faculty members of the Department of Physics & Astronomy have been the leaders in shaping the design of RIA into a bold new concept. Placing RIA at MSU is one of the highest priorities of the University. The nuclear physics group of the Department of Physics and Astronomy is the driving force of the effort to attract RIA to MSU, and it is the unanimous consensus of the department to support this effort.

After the RIA decision, planning for the academic accelerator physics program will need to be revisited.
The departmental effort in accelerator physics is still sub-critical, with only one faculty member in theoretical beam physics (Berz, not a member of the NSCL)

and one joint faculty member (Schriber) working at the NSCL. A strong graduate program in experimental accelerator physics exists at the NSCL, but the graduate students in the NSCL program are predominantly supervised by adjunct professors. The details for implementation of the departmental accelerator physics group(s) could be different, depending upon where RIA will be built. Therefore the detailed strategic plan for implementation should be developed by the department after the RIA decision has been made. However, independent of the decision on RIA, accelerator physics remains a critical need for the future of the nuclear physics group and the strength of the department. Both the department and the NSCL have achieved significant visibility in the field and should continue to explore ways to strengthen these efforts.

Important science opportunities in experimental nuclear spectroscopy, in Atomic, Molecular, and Optical physics (AMO), and in nuclear astrophysics need to be pursued aggressively. One or two faculty hires are needed to replace anticipated retirements.
The successful completion of the Coupled Cyclotron Facility at the NSCL in 2001 transformed the laboratory into one of the leading rare isotope research centers in the world. In order to accommodate the growth of the laboratory, Thomas Glasmacher moved to an administrative position at the NSCL. He was appointed as Associate Director for Operations at the NSCL, increasing the number of Physics and Astronomy Department faculty members with major management duties at the NSCL to three (Gelbke, Thoennessen, Glasmacher). On the other hand, a strong in-house experimental group is essential for the success of the NSCL and the number of faculty members actively involved in research has to be maintained.

Three general areas offer new and exciting physics opportunities and large discovery potential. The spectroscopy of exotic isotopes and the measurement of key data for a quantitative understanding of the important nucleosynthesis processes are some of the highest priorities of the nuclear physics community according to the last NSAC long rang plan. In addition, the recently installed LEBIT facility offers new opportunities to branch out into atomic and molecular physics. Searching for faculty in these targets of opportunities should be pursued aggressively.

Theory of cluster science and mesoscopic systems provides exciting new interdisciplinary science opportunities, and the establishment of a center should be pursued aggressively.
The scientific community is witnessing the birth of a new area of physics that will supplement traditional macrophysics of large systems and physics of the microworld, namely mesoscopic physics and cluster science. This classification can be applied to systems that are sufficiently large to display generic statistical regularities but at the same time sufficiently small to allow the researchers to

study in detail, theoretically and experimentally, individual quantum states. The future successes of fundamental physics and technology are in the direction of mesoscopic systems, such as atomic and metal clusters, complex molecules including fullerenes and biological molecules, quantum dots and various other nanoscale solid state systems, Bose and Fermi gases in atomic traps, and the elementary units (qubits) of future quantum computers. A quantum computer is an ultimate mesoscopic system, which is fully controllable and, besides other applications, will enable qualitative and quantitative tests of the mesoscopic theory.

Although on a much smaller length scale, nuclei are prototype mesoscopic systems. They exhibit one of the richest variety of mesoscopic phenomena, some of which are linked to individual nucleons, others to the collective behavior of the nucleus as a whole or to correlations among a small number of nucleons. This richness has lead nuclear theorists to develop diverse and powerful many-body methods over the last decades. It is only relatively recently that these ideas and methods have started to be used, and in some respects advanced, in their applications to other finite quantum systems of current interest.

The proposed mesoscopic physics center would combine the expertise of the nuclear theory group at MSU with theorists from the solid state group and from theoretical chemistry. The strength of these theoretical groups is augmented by the interactions with the strong experimental groups in nuclear and solid state physics at MSU. We would pursue the broad and interdisciplinary theoretical problems that tie together the properties of mesoscopic systems. These topics include: the transition from microscopic to mesoscopic; the transition from mesoscopic to macroscopic; the properties of loosely bound and open systems; coherent phenomena; quantum chaos; quantum control; quantum transport and advanced computing.

Need for two additional permanent academic support staff positions for teaching program.

The PA teaching program is taking on ever-increasing numbers of students. During the last decade, the number of physics majors has approximately doubled. Several new courses and many new sections for non-majors have been created. PA is taking the lead on many areas of technology in teaching (LON-CAPA, audience response systems, wireless access). Finally, physics and astronomy are high-tech sciences, and our teaching program needs to reflect this with ever-more sophisticated teaching laboratory set-ups. In order to remain a national leader in physics and astronomy teaching, it is imperative that we strengthen our teaching support personnel. At present our teaching program could not function properly without Tibor Nagy and Richard Hallstein. And yet, we are forced to pay them with funds we have to scrape together annually. In order to retain them in the department, PA has to work together with CNS and the

Provost's office to create a more permanent employment situation for Nagy and Hallstein.

ii. Academic programs – describe plans to improve/enhance existing programs, introduce or eliminate programs, identify emerging areas, and enhance student recruitment. Describe potential innovations in the classroom, including global perspectives and the use of instructional technology.

We subdivide our remarks into three categories: technology, undergraduate, and graduate programs.

Instructional Technology:
Course management system: LON-CAPA use and development continues to be our highest priority. We are actively working to win partners from other institutions and to extend the LON-CAPA network. LON-CAPA's success depends on strong support and leadership from PA. It is our view that MSU as an institution needs to take a position of strong leadership to advance this course management system. This will help the university position itself as a leading university in the 21st century.

Audience response systems: Several PA faculty have taken the lead in experimenting with audience response systems. We will continue to use the IR-based technology currently installed in 1410 BPS and the planetarium, but will also experiment with RF-based approaches, consistent with guidelines recently released by MSU. Audience response systems are continuously improving. In just a few years much better two-way communication will be possible, leading to a much more interactive new model of a classroom lecture.

Virtual university: PA has taken a leading role in the development and implementation of virtual university classes and modules, also for dual use with conventional lecture units in hybrid environments. It can and should be expected that this leadership position will continue as we experiment with new technology and methodology.

Undergraduate Programs:
New course: Biological Physics is an important emerging area in physics. The Department has recently hired two faculty members with research interests in this field (Wedemeyer and Lapidus) and expects to appoint other new faculty in this field in the future. We propose a biological physics course primarily aimed at students majoring in physics; students from other majors, e.g., biochemistry or physiology, may also find it to be an interesting course. The prerequisites for Biological Physics will be introductory physics (PHY 183 and 184), modern physics (PHY 215) and differential equations (MTH 235). It will be a 3-credit

lecture course on the junior or senior. This course will introduce students to recent progress in biology that is based on methods of experimental, computational and theoretical physics. Some examples of topics that may be included are: protein structure and function, protein and RNA folding on slow and fast time scales, computational methods for protein structure, evolutionary modeling, systems biology, and biomedical applications. This course will add a multidisciplinary component to the Physics/Astronomy undergraduate program, which may grow in later years due to research programs such as the Quantitative Biology and Modeling Initiative. The Department also plans to designate Biological Physics as an optional Capstone Course for the BS degree in physics, for students with a particular interest in biophysics. Some MSU physics majors go to graduate school in Medical Physics after receiving the BS degree, and the Biological Physics course will enhance their preparation for a career in biophysics research.

Alumni relations: The Department has always maintained a thorough database of alumni in Physics and Astronomy. This database is used for mailing the annual Departmental Newsletter to our alumni. However, we have not kept detailed information on the careers and job placements of students who graduate from MSU in physics or astronomy. The goal of this plan is to develop and keep detailed information on the careers of our graduating seniors. We plan to start collecting more detailed information on the career paths of our students by conducting a survey of recent graduates (who received a Bachelors degree in the past 5 years). We will ask for information about the employment of these former students, comments on the value of the physics education that they received at MSU, and suggestions for improvements to our educational program

Graduate Programs:

Advanced courses: Due to rapid growth in many areas of physics and interdisciplinary sciences, it has become necessary to cover many of these new developments in graduate physics core courses. This is difficult, because one has also to cover basic materials in these courses. In order to circumvent this problem we propose to introduce several ½-semester 2-credit courses in emerging areas of physics, such as Biological Physics, Quantum Computing, Nanostructured Materials, General Relativity, Novel Many-Body Techniques, etc. The goal is to introduce up to 12 such courses, three of which will be given in a given term. The exact course titles and the mechanics of incorporating them in our curriculum will be worked out.

Ph.D. program review: The department restructured the Ph.D. comprehensive examination requirements more than five years ago. Instead of a single comprehensive examination covering different areas of physics we introduced subject examinations in four core courses. The Astronomy Ph.D. requirements have also been revised during last five years. In addition to Physics and Astronomy Ph.D. programs we have several interdisciplinary Ph.D programs given jointly with Biochemistry and Chemistry. These programs are expanding. In order to make our Ph.D. program more flexible and to accommodate the requirements of different departments (for the joint Ph.D. degree) we are planning to reassess our Ph.D. degree requirements in the very near future.

iii. **Research and scholarship** – describe the core research thrusts of the unit. Identify new funding opportunities, emerging areas for emphasis and collaborations (across disciplines and with industry). What opportunities may exist for new research centers; for training grants; for commercialization? Identify existing and emerging interdisciplinary initiatives that should be supported and promoted.

The PA strategic plan for our research enterprise does not contain drastic changes. We have been the most successful department on campus in terms of federal grant support, and we need to make sure that our strong federal funding remains stable in the near and intermediate future. Retaining our large research grants in NUC, CMP, HEP, and increasing our external research support in AST are our top priorities. We anticipate a further erosion of federal research support nationally during the next few years, with a resulting increase in the intensity of the competition for ever-scarcer resources. To remain competitive in this environment requires a continuation of commitment of faculty lines, as well as a stable research infrastructure support (machine shop, electronic shop, clean room, computer support).

A full utilization of the SOAR telescope, with a successful completion of the Spartan Infrared Imager as a cutting edge research tool are essential for the future success of our AST group. Additional investments into this group should be considered, if this leads to a further increase in external funding and stature of the group and department. In this context, joining a large international astronomy collaboration for a next generation instrument should be considered within a 5-10 year window.

Finally, the PA strategic plan recognizes that the impending decision on RIA construction will have very large ramifications for the future of our department (and College!). Thus we need to keep in mind that our plan will need refinement once the RIA decision has been made.

PA identifies the following three top priorities for new development and investment:

Nuclear and particle astrophysics
Obviously, RIA continues to be a top priority for MSU as an institution. We have worked hard to refocus our science program in nuclear physics to align ourselves with the science program needed for RIA. In addition, we have managed to build interdisciplinary bridges between nuclear and astro-physics, and between astro- and particle physics. This has resulted in the award of the NSF Frontiers JINA Center, as well as the MSU CSCE REF Center. We will need to continue to invest in this area to make sure that we retain our national and international leadership position.

Complex materials
During the last two decades, the collaboration between CEM and PA, and between Engineering and PA, in the field of complex materials has been extremely fruitful. Participating departments have made strategic hires in this area and have achieved strong national prominence. We need to continue to provide strong support for materials research at MSU. This includes branching out into new and promising fields such as new materials for quantum computing and quantum control.

Biophysics
Biochemistry, PA, and CEM have formed a very promising collaboration at the interdisciplinary interface between the physical and life sciences. This collaboration needs additional interdisciplinary faculty hires to build a nationally recognized core program. Very strong NIH funding potential exists, and exciting discoveries can be expected.

iv. **Service and engagement** – describe how your unit will interface with the public and private non-academic sectors.

We believe that a strong outreach program is vital, because increasingly the general public has to be convinced that funding science is in their interest. Our two most important venues to interact with the general public and K-12 audiences will continue to be the Abrams planetarium as well as the NSCL. The planetarium's main mission is outreach, with thousands of visitors each year. The NSCL has long recognized that a strong outreach component is an essential part of the mission given to it by the NSF. Several thousands of visitors tour the NSCL each year. Our particle physics group has established a strong outreach presence through its coupling to the national outreach efforts of the particle physics community, such as project Quarknet, for example. All of these efforts will continue.

Our main conduit to the private non-academic sectors remains our condensed matter group. This group's research output has perhaps the strongest immediate technological application, and areas like quantum control and quantum computing, as well as complex materials and biophysics will rise to the forefront of the public's attention in the years to come.

v. **Diversity and quality of faculty, staff and students** – suggest ways to enhance the education and participation of underrepresented groups in your unit activities, and to raise the unit's ranking and reputation.

We have been very successful in increasing the fraction of female faculty, hiring three tenure track and one tenured female professor, one joint NSCL/PA faculty, plus two additional female research faculty. In several instances, these new faculty members have brought in female post-doctoral associates or helped recruit female graduate students, serving as role models. We expect this trend to continue and to amplify. We also hired one male faculty member from and underrepresented minority group. With more minority and female faculty, we expect that the trend towards a more diverse graduate and undergraduate student body will continue, with the highest qualified underrepresented minority members electing to come to MSU, partially because of the presence of strong role models.

vi. **Development** – indicate how your unit will increase private support as both state and federal funding become more limited. How will individuals, corporations and foundations become more involved with unit activities?

During the last few years PA has increased attention and devoted some financial resources to our newsletter and web site, in order to establish better connections to our alumni. In addition, we have made conscious efforts to provide a strong presence at alumni gatherings and give presentations around the country. This has paid some dividends, often from rather unexpected sources, resulting in endowments of scholarships and strong support for our SOAR telescope and new science building. We plan to continue this approach and tell our story in the newsletter, on our web site, through presentations to alumni groups, and in person-to-person meetings with potential donors. Astronomy has the advantage that everybody is curious about the origins of the universe, and physics is the quintessential high-tech science. We plan to build on these advantages.

vii. **Initiatives at the College and University level** – suggest programs, activities and initiatives that would enhance the research, education and service missions of the unit. Are there College organizational changes that might help your unit more effectively reach its goals?

The most important interdisciplinary research activities from the perspective of PA are nuclear science (collaboration with the NSCL and Chemistry), accelerator physics (collaboration with Mathematics and Engineering), biophysics (collaboration with QBMI, Biochemistry and Chemistry), complex materials (collaboration with Chemistry and Engineering), quantum science (collaboration with Mathematics and Engineering, IQS), and the LON-CAPA course management and learning system (collaboration with LBS, DSME, Computer Science and Engineering). These interdisciplinary connections will remain vital to our research programs, at least for the next five years.

The initiative on cyber-infrastructure has the potential to be of very strong benefit to PA, CNS, and MSU as a whole. It is vitally important that MSU recognizes the increasing importance of computing and information technology in all aspects of our profession, and PA is prepared to take a leading role to bring this change about. An increased investment in and institutional commitment to LON-CAPA is essential for this system's success. But it is also an opportunity for MSU to step into a national leadership role. Computing software and hardware for the future need to be a very high priority for the MSU research infrastructure. The investment into the Institute for Quantum Science (IQS) is a very encouraging first step, and future collaborations with the College of Engineering, and in particular with the Computer Science department could be very beneficial to both sides.

With our biophysics initiative we have broken new ground on a tighter coupling between the physical and life sciences. PA is taken a leadership role in the QBMI REF Center and plans to continue this in the future. Additional possible venues for future investment could be medical physics, but preliminary talks with the Department Radiology as well as the College of Human Medicine on the possibility of establishing a medical physics program are still in their infancy.

PA took a very active role in the discussion on college reorganization. Through these studies we have come to the conclusion that a merger into a large liberal arts and sciences college is absolutely not in our unit's interest, and we will continue to fight against such a reorganization. However, there may be other reorganizations, in particular those that also involve the "professional" colleges, which may be beneficial. We remain open to take part in continued discussions.

E. Indicate the metrics, benchmarks or indicators that will be monitored to determine the degree to which your unit is progressing toward its goals, or that will be used to make decisions about modifications or changes to the goals over time.

i. Faculty/staff recruitment – how has the composition by area met expectations? How has diversity improved?

The American Institute of Physics publishes regular statistical summaries of composition of physics faculty around the country. These data should be used as benchmark comparisons for our success in improving diversity, participation of underrepresented minorities, and other statistical measures of departmental composition.

ii. Academic programs – how well does the unit prepare its graduates for the competitive job market? How are you monitoring student learning and using the results to drive change? How are you being responsive to changing student demographics and changes in the post-graduate marketplace? Metrics would include such things as quality of student recruits, job placements, alumni surveys, student course evaluations, specific learning outcomes, etc.

For more than a decade, PA has taken the leadership in measuring student learning in the large enrollment introductory courses, most recently within the LON-CAPA course management and learning system. This system contains a wealth of tools for measuring student satisfaction and student success. Measurement of learning outcomes is available both in statistical form as well as in narrative form. Several PA faculty, in collaboration with DSME, LBS, and other units, are engaged in active research programs to measure learning success and to improve it.

PA is putting in some efforts to track our students after graduation. We keep this information in a database that we also use to send out our newsletter. We collect anecdotal data on learning outcomes, alumni success, job placements, and other measures of graduate success through conversations with individual alumni. However, we have yet to complete a statistical alumni satisfaction survey. If resources become available, this task would certainly be high on our priority list.

iii. Research and scholarship – indicate various metrics for monitoring progress in scholarly activities, e.g., NRC rankings, peer comparisons, research funding, publications and citations, national and international awards.

Federal funding agencies release funding summaries for each institution and for each department. In addition, all physics and astronomy departments undertake a detailed process of self-reporting in the annual handbook of graduate programs, issued by the American Institute of Physics. These two sources are the most objective measures for success of PA in terms of extramural grant funding.

Citation rankings are the least biased means of measuring research quality in the physical sciences. Several organizations, such as Science Watch, or the American Physical Society, compile periodical rankings of departments and publish them.

Federal funding and citation ranking are the most objective measures. All other rankings all more subjective, rely on somewhat arbitrary criteria, or are almost purely a popularity contest. The National Research Council ranks graduate programs approximately once per decade. But this ranking relies strongly on individual's subjective judgment of other programs. And of course there is the ever-popular US News annual ranking exercise.

PA keeps track of these various rankings and publishes them on our web site: http://www.pa.msu.edu/ranking.htm, because we feel that our rankings compared very favorably and are a recruitment tool for faculty and students.

iv. Other indicators – such as increased development activities, industrial relations, patents, outreach, quality of students.

Development income is of course easy to measure. However, there are several conceptual difficulties in using this number for comparison purposes. Size of the alumni base, attractiveness of the research topics to donors, and financial success of alumni vary just too strongly from department to department and between institutions to be able to use development activity as a reliable measure of departmental success. Similar reservations hold for industrial relations and patents, as well as outreach activities.

Quality of incoming students is more easily quantifiable (SAT, ACT, …), but is more a measure of the current reputation of the institution as a whole than that of a given department.

2. Evaluation of Interdisciplinary Scholarship and Educational Programs

We should revisit the identification of interdisciplinary thrusts that involve CNS units, most recently considered in 1998. Are the interdisciplinary research thrusts now different? What are they? How should such areas as computational science, materials science, environmental science be viewed now? What about the biomedical research thrusts? Science and mathematics education? How might both undergraduate and graduate programs be altered to better represent multidisciplinarity?

This was already addressed in the answer to 1.D.vii

3. Evaluation of the College Strategic Directions

We will consider modifying, adding or deleting items from the previous list, developed in 1996. This should not be difficult in light of the responses to item 1D, and the discussion around item 2. We must be mindful of connections with other colleges and alignment with overarching University missions and priorities.

Again, this was already addressed in the answer to 1.D.vii