University of Colorado **Boulder**

2017 Program Review

JILA

Academic Review and Planning Advisory Committee Report

Approved

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Provost and Executive Vice Chancellor for Academic Affairs: Date

Contents

Process Overview

The review of JILA (formerly known as the Joint Institute for Laboratory Astrophysics) was completed in accordance with the 2017 review guidelines. The Academic Review and Planning Advisory Committee (ARPAC) conducts and writes the final reviews of all Boulder campus academic units. The institute prepared a self-study during 2016, which was checked by an internal review committee in early 2017. The internal reviewers held meetings with JILA personnel and administered graduate and undergraduate student surveys. The internal reviewers also met with the JILA chair and the JILA chief of staff and the division chief and the administrative officer of the National Institute of Standards and Technology (NIST). The internal reviewers scheduled open meetings, during which it met with three JILA Fellows, two staff members, one postdoctoral fellow, and two graduate students. A four-person external review committee, visited the institute on April 13 and 14, 2017. The external reviewers reviewed relevant documents and met with faculty, students, staff, university administrators, and ARPAC members. Internal and external review findings are cited at appropriate points throughout this report. This public document reflects the assessment of and recommendations for JILA as approved by ARPAC.

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Unit Overview

The campus' standardized description of the institute and information regarding comparable units may be found on the Office of Data Analytics (ODA) website at https://www.colorado.edu/oda/institutional-research/institutional-level-data/information-department/academic-review-and-planning. ODA updates the JILA profile annually in the fall semester. This report cites the ODA data for JILA posted in October 2016, the most recent update available; these figures reflect the state of the institute in academic year (AY) 2016-2017. More recent data from the self-study is cited where appropriate.

JILA was founded in 1962 as a joint venture with the National Institute of Standards and Technology, an agency of the U.S. Department of Commerce. Initially focused on laboratory astrophysics, JILA has developed to include astrophysics, biophysics, chemical physics, precision measurements, and atomic, molecular and optical (AMO) physics. It would not be an exaggeration to describe JILA as a crown jewel of the university. Its members include three Nobel laureates, nine members of the National Academy of Sciences, and three recipients of a MacArthur "genius" fellowship. It is the paradigm of a successful interdisciplinary research institute, with physics, nanoscience, materials, chemical physics, optics, and precision measurement located within the same facility. JILA has a worldwide reputation for pioneering research, conducts a great deal of collaborative work, has a strong sense of community, and receives significant group funding. According to the self-study, collaboration is particularly strong among different research groups in physical chemistry, optics, biochemistry, biophysics, and condensed matter physics. *U.S. News and World Report* ranks the AMO program first in the country (2014 rankings).

Personnel and Governance

According to the self-study, as of November 2016 JILA had 27 faculty, known as JILA Fellows, including three new associate JILA Fellows added in the past seven years. Eighteen JILA Fellows are rostered in CU Boulder departments—Atmospheric and Planetary Sciences, Physics, Chemistry, and Molecular and Cellular Developmental Biology—and nine are National Institute of Standards and Technology (NIST) employees. CU Boulder-based JILA Fellows hold full-time teaching appointments; NIST-based JILA Fellows generally hold adjoint or lectureship appointments. There are three adjunct JILA Fellows from Physics There are also 12 adjoint JILA Fellows, former JILA Fellows or associate JILA Fellows whose previous appointment has been terminated due to retirement or a change in permanent residence or employment status. Although their status varies—e.g., some have emeritus status, some do not—adjoint JILA Fellows retain voting rights in governing matters. In addition, the self-study reports that JILA includes 52 postdoctoral researchers, 24 administrative staff members, 25 technical support staff members, approximately 109 graduate students participating in the institute in various ways, and 13 visiting JILA Fellows and other scientists. The self-study also reports that in AY 2016-2017 JILA was conducting an open search, looking for up to two scientists to fill recently vacated NIST positions, although the institute does not necessarily try to hire faculty in the same areas of research engaged in by previous faculty. Rather than hiring directly, CU Boulder-rostered JILA Fellows are hired through campus departments. JILA has more control over its NIST hires, although of course these also must be approved by the agency.

JILA has an annual operating budget of $27.6 million. NIST provides 24% of this total for research, salary and infrastructure; CU contributes 14%, and the rest is provided by federal and private grants and other sources Thus, JILA is more

dependent upon federally funded, competitive grants and less dependent upon funds from the campus general operating budget than are most other campus units.

The JILA Fellows govern the institute under the authority of a memorandum of understanding (MOU) between the University of Colorado and the National Bureau of Standards (currently, National Institute of Standards and Technology - NIST). The JILA Fellows make collective decisions in coordination with both NIST and CU Boulder academic units. The chair is elected by the JILA Fellows and serves first a two-year term as associate chair, then another two-year term as chair. The chair alternates between CU Boulder- and NIST-affiliated JILA fellows. The chair oversees institute administration in collaboration with the JILA Fellows' executive committee, the institute's chief operating officer, and NIST administrative officers.

Research and Scholarship

Given its technical nature, it is possible here to describe the institute's research in only a general and selective way. Although this brief description fails to do justice to the wide range of the institute's research, which extends from quantum physics to astrophysics, it suffices to indicate the extraordinary nature of the institute's work. As JILA is unusually interdisciplinary and collaborative, its research activities also may be grouped in various ways. The institute's website identifies eight distinct research areas. The self-study, however, divides the institute's activities into six areas, as follows: First, the Astrophysics Group consists of four JILA Fellows and one Associate Fellow. This group does theoretical and computational research in the areas of astrophysical fluid dynamics, exoplanets, black holes, and cosmology. Second, the Experimental AMO Physics group has nine JILA Fellows, as well as three adjunct JILA Fellows with related research

programs. This group has a research program utilizing ultracold atoms cooled to within millionths and even billionths of a degree above absolute zero. Some of this group's achievements include realizing the first Bose-Einstein condensate, an achievement recognized with a Nobel Prize in physics, pioneering the field of degenerate fermions, and exploring how to create atomtronics, which are the analog of electronics but with ultracold atoms. This group also has been active in extending the control techniques for atoms to molecules. Third, the Theoretical AMO Physics group consists of six JILA Fellows and one Adjoint JILA Fellow. This group covers all the important areas of contemporary AMO physics research, including ultrafast AMO physics, ultracold AMO physics, the overlap of AMO and condensed matter physics, and quantum information theory. Collaboration between theorists and experimentalists is a central aspect of AMO physics at JILA. Fourth, Chemical Physics includes a core of four JILA Fellows. This group encompasses several topics at the interface of experimental chemical physics and biophysics, including femtosecond spectroscopy, studies of protein dynamics and photophysics, and the development of microfluidics-based optical tools to explore biomolecular function. Fifth, Biophysics research, which is also coupled with Chemical Physics research, comprises three JILA Fellows. Among other areas, this group has developed optical trapping to establish expertise in high accuracy, high sensitivity atomic force microscopy. Members of this group also focus on the kinetics and dynamics of tertiary/secondary structural transitions in biomolecules. Finally, Precision Measurement includes eight JILA Fellows and three adjunct JILA Fellows whose work is primarily in this area. JILA is a world leader in utilizing ultrafast pulses of light with durations in the femto-to atto-second regime. Members of this group have advanced the frontier of time and frequency metrology to new record

precision and accuracy. JILA has also accomplished impressive theoretical and experimental advances in areas such as atomic clocks, state squeezing, precision spectroscopy (eEDM), XUV laser frequency combs, and coherent x-ray.

Viewed in broader perspective, JILA members publish approximately 200 original scientific papers per year and bring in approximately $25 million per year of external funding from sources such as the National Institute of Standards and Technology, the National Science Foundation (NSF), the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration (NASA), and various private sources. In the words of the external reviewers, JILA is a "rare treasure" for the university.

Graduate Education

Graduate training is fundamental to the institute's activities. JILA enables students to pursue cross-disciplinary studies not possible in parent departments. JILA Fellows not only teach graduate courses in their own departments but also devote a great deal of energy to graduate training in their capacity as PhD advisors. Of course, graduate students also conduct research in collaboration with JILA researchers. A significant number of JILA Fellows sit on graduate admission and comprehensive examination committees in the departments of Astrophysics and Planetary Sciences, Chemistry and Biochemistry, and Physics. JILA supports graduate student travel to conferences, enabling students to learn about the latest research and to make professional contacts. Graduate students also can take training courses from JILA in electronics, electron microscopy, computing, machining, and scientific writing. There are regular "Life after JILA" program meetings at which JILA alumni discuss subjects related to career development. JILA PhDs have been highly successful in winning awards and postdoctoral fellowships.

In the internal review survey, some graduate students expressed a desire for more regular mentoring in order to ensure more even progress towards graduation. They also asked for the establishment of more regular, formal scientific communication, perhaps through a student seminar series. It may be that students working at JILA sometimes fall out of scope among those they might depend on to track their professionalization.

Although the internal reviewers conducted a survey of graduate students, neither the institute nor ARPAC surveyed postdoctoral fellows to ascertain their general satisfaction with and opinion of the institute's climate. There also is no information offered in the self-study about the job placement of graduate students and postdoctoral fellows who have worked at JILA. This is not surprising: although JILA members are extensively engaged in various forms of graduate training, the institute currently relies upon member CU Boulder departments to provide mentorship, academic oversight in general, and presumably the monitoring of matters such as job placement. Nevertheless, it may be useful for JILA to collect more information about postdoctoral fellows' opinions of the institute and their subsequent job market experience.

Undergraduate Education and Outreach

A full-time postdoctoral fellow oversees the institute's education and outreach activities. Again, a few examples must suffice to illustrate the institute's wide range of activities. According to the self-study, there are approximately 20 undergraduate students working in JILA-associated research groups. An additional 15 participate each summer through the National Science Foundation's Research Experience for Undergraduates Program and through the National Institute of Standards and Technology's Metrology and Technology Research Opportunities Program (MeTRO), which is funded by

NIST with a $100K per year grant to CU Boulder. The NSF Engineering Research Center located at JILA supports several undergraduates. JILA participates in the Physics Education Research (PER) group at CU Boulder. PER studies the use of technology in physics education as well as other ways of improving science education.

In terms of outreach, the institute's Physics Frontier Center (PFC) provides support for simulation programmers, and PFC senior investigators have worked on content development for AMO-related simulations or "sims." PhET sims (a name derived from the Physics Education Technology project, now known by its acronym PhET) provide a computer-game-like context for children and adults to learn about basic and cutting-edge science. According to the self-study, over nine million sims have run online or been downloaded in the past year, and these sims also have been translated into more than 48 languages. JILA personnel have given talks on atomic clocks at AnomalyCon, Denver's premier science fiction, steampunk and alternative history convention. One JILA Fellow has collaborated with the Denver Museum of Nature and Science and PBS's *Nova* program to create two large format high-resolution dome shows and an associated *Nova* TV show on black holes. The CU Wizards Science Outreach program has involved a dozen or more JILA faculty and presents ten shows each year to hundreds of lower-primary school (K-6) students and parents. The quarterly JILA publication *Light & Matter* explains the institute's research not only to those inside the institute but also more broadly to faculty and students across campus, as well to the general public. Additional outreach activities pertaining to inclusive excellence are discussed below.

Space

JILA is located on the Main campus in the Duane Physics complex, which contains offices, labs, instrument and electronic shops, and computing staff and facilities, as well as more specialized shared facilities such as the Keck Optical Measurements Laboratory and a clean room, which serves not only JILA Fellows but also many other CU scientists and some in private industry. Starting from the street (Colorado Ave.) and going southwest toward the Imig Music building, one first comes to the B wing, then the Tower, which is the A wing, then the S wing, then the X wing. JILA uses facilities in all these wings, particularly the new X wing, which constitutes a 50,000 square foot advanced laboratory expansion. Despite this new wing, the self-study reports that JILA is using approximately 90% of the available space and that with the addition of two new faculty JILA soon will be at capacity. The self-study notes that the A and B wings are now over fifty years old and with urgent refurbishment needs and reports that the S-wing has serious problems with heating, ventilation, and air conditioning capacity, control, and distribution systems. Lack of adequate environmental controls makes it difficult or impossible to do cutting-edge experiments involving atomic clock development, and recent power outages have resulted in damaged equipment, lost time, and research productivity. The institute's concerns about space echo complaints from the Department of Physics that it is out of office space, is pressed for teaching space, and has critical needs for both new and refurbished labs. For these reasons, the JILA Self-Study strongly supports Physics' request for the construction of a new Duane Physics H wing. Assuming Physics is provided with new space, JILA would move into what Physics has vacated. A second suggestion made in the self-study is to build new space onto the S wing, which was originally designed to hold three extra floors. JILA could then move onto the first floor, which was

originally designed for labs, thereby displacing current offices to the new space.

JILA has already launched some exploratory projects with respect to space and facilities. It has conducted a planned outage to test the existing generator and electrical systems, for example. Although it is still processing information from this project, JILA estimates that improvement to electrical back-up systems will cost more than $1 million. JILA also has initiated work with Facilities Management to install sensors to record and monitor lab conditions throughout the S and B wings. These will have to run approximately one year to provide data for possible solutions. Finally, Opterra Energy Services did a technical energy audit of JILA facilities and recommended improvements that could save energy and improve heating, ventilation, and air conditioning stability. The improvement cost is estimated at slightly over $4 million.

Staffing and administration

The 2010 ARPAC report and the 2017 internal reviewers recommend that the institute develop a more detailed hiring plan. In response, the institute says that it is difficult to search for a candidate in a particular discipline, given the institute's highly interdisciplinary nature. Rather than composing a detailed plan, JILA members have agreed upon some general principles to guide hiring and have created an unranked list of target hiring areas. The principles are that any new hire must contribute to the institute's scientific leadership by helping to maintain a critical mass of practitioners, must respect JILA Fellows' self-determination of scientific direction, and must maintain the institute's strong collaborative culture and community. The areas on the institute's unranked hiring list include instrumental astrophysics, precision measurement, chemical physics, biophysics, and ultrafast optics. JILA notes that when hiring in molecular science, chemical physics, and

ultrafast laser science, “it will be essential to maintain and extend coordination with the Physics, Chemistry, and Biochemistry, as well as the Engineering departments at CU in order to leverage resources for future hires.”

JILA has several concerns about research administration. The self-study acknowledges that some of the issues may be traceable to external regulations, but it seems that some may result from poor communication within CU Boulder. JILA is concerned that the Office of Contracts and Grants (OCG) and Sponsored Projects Accounting (SPA) office may not be serving the purpose of supporting communication and coordination between research administration and researchers, including about federal and sponsor regulations and requirements. It is possible that OCG and SPA staff increases are needed to provide the support that researchers need. The self-study encourages the university to consider additional financial investment in improving administration and asks the university to embed some administrative staff in JILA to improve understanding of research and promote communication between researchers and administration.

Inclusive Excellence

As already noted, JILA personnel display a strong climate of collegiality and cooperation. There is also extensive informal mentoring of associate JILA Fellows, who of course are formally mentored through their parent departments. Students also seem to find JILA quite collegial, although the picture here is a bit cloudier. The internal reviewers conducted a student survey to which 9 of 22 undergraduate students and 55 of 118 graduate students working with JILA responded. Both undergraduate and graduate students were largely “satisfied” or “very satisfied” with their JILA experience. One of nine undergraduate and seven out of 55 graduate student respondents disagreed or strongly disagreed, however, with the

statement that “JILA encourages a climate that is tolerant and respectful of diversity.” Student comments in the survey do not shed any light on why some are dissatisfied with the institute’s climate. Although the number (as opposed to percentage) of dissatisfied respondents is small, this dissatisfaction is nonetheless of some concern. JILA plans to explore this matter further in order to make specific improvements.

Although it remains an important goal of JILA to increase the number of minority and female faculty and students, diversity efforts are somewhat hampered by the fact that much faculty hiring and all student recruitment is done through departments. Even with this limitation in mind, it should be noted that the self-study provides no information about minority representation among faculty, graduate students, postdoctoral fellows, and staff. The self-study also does not mention any specific programs to improve minority representation, except for the Katharine Burr Blodgett Fellowship, which is targeted to recruit underrepresented minority and women graduate students at JILA (and which two women have received since the last review cycle). In the internal review survey, one graduate student also noted that all of the machinists, electronics shop, and computing staff are white or Asian males.

JILA has yet to provide an inclusive excellence narrative. The institute’s record regarding inclusive excellence is clearer with respect to gender than with respect to underrepresented minorities. Six JILA Fellows are women, with five employed as CU faculty and one employed by the National Institute of Standards and Technology More than 29 percent of the institute’s graduate students are female, as are 25 percent of its senior research associates. The self-study reports specific efforts to provide role models for graduate students and postdoctoral researchers, to create mentoring opportunities for

women, to recruit and promote women administrators, to promote safe and accepting campus spaces, to ensure salary equity, and to support work-life balance and flexibility on family issues. To encourage equity for both men and women, JILA enforces a bounded salary range for postdoctoral researchers, for example. With the help of NIST, JILA also has been able to be flexible in dealing with spousal/partner hires.

JILA has a number of outreach projects for underrepresented student populations at the K-12 levels. The PFC Partnerships for Informal Science Education in the Community (PISEC) program provides opportunities for undergraduates, graduate students, and postdoctoral fellows to teach in K-12 populations that are underrepresented in science. Other partnerships with JILA include the Mathematics, Engineering, and Science Achievement Program (MESA), which involves teachers who recruit children from underrepresented populations; JILA also partners with MESA to provide science instruction.

Past Reviews

The 2010 ARPAC review asked the institute to address staff concerns that were contributing to low morale, especially concerns about job security and lack of recognition for staff accomplishments. While the self-study does not identify specific responses to this recommendation, it does note significant training opportunities for staff, as well as a regular awards program for special staff contributions. Another previous ARPAC recommendation was that JILA revisit its bylaws to address how it guarantees cross-disciplinary and cross-rank representation on the executive committee. The self-study does not explain how JILA has responded to this recommendation specifically, and indeed the current bylaws state that "[w]e do not see any gaps or areas requiring revision [to the bylaws] in the future." Two other 2010 ARPAC recommendations were that the institute participate fully in campus initiatives to increase the representation of underrepresented groups in the natural sciences and that it work with the CU Foundation (now the Office of Advancement) to increase private philanthropy to fund competitive scholarships and fellowships targeted at increasing the number of undergraduate and graduate students from underrepresented communities in degree programs affiliated with JILA. Again, the self-study reports no specific responses, although it does explain in general how JILA has tried to improve diversity and inclusivity. In addition, the last ARPAC review made several recommendations about matters that reappear in the current self-study, internal and external review assessments. As discussed elsewhere in this report, these include needs for new and refurbished space and facilities, a more detailed hiring plan, the reduction of administrative burdens, and a new plan for private philanthropy.

Campus Context

Members of JILA interact with many different campus departments, centers, and colleges. To mention a few, these include the departments of Physics and Chemistry and Biochemistry, the Center for Astrophysics and Space Astronomy (CASA), the Laboratory for Atmospheric and Space Physics (LASP), and several parts of the School of Engineering and Applied Science. As noted above, JILA Fellows provide a great deal of graduate training to the campus, and many of them also are involved in undergraduate education and in public outreach. Campus recognition of the institute's many outstanding achievements and contributions may be indicated by listing just a few of the top university awards JILA members have received, including the CU Faculty Fellowship, the CU Professor of Distinction Award, the CU Technology Transfer Award, and the Hazel Barnes Prize.

Disciplinary Context

One distinctive way in which JILA makes an important national contribution is through its relationship with the National Institute of Standards and Technology, which has major laboratories in Boulder and Gaithersburg, Maryland. The National Institute of Standards and Technology is a world leader in measurement science research with the mission of "promoting U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life." JILA Fellows collaborate closely with NIST-based scientists, and postdoctoral fellows, graduate students, and undergraduates perform research at the NIST Boulder facilities. As previously noted, nine of the 27 JILA Fellows are NIST employees with adjoint faculty appointments in CU Boulder departments. NIST-based JILA Fellows perform the same research, advising, and service as CU Boulder-based JILA Fellows and also do some teaching but are fully paid by NIST. NIST contributed approximately 24% of the JILA annual budget for 2016 and also recently provided the university with $22.5 million through a cooperative agreement as the major source of funding for the JILA X wing. Supported by NIST, the visiting JILA Fellows program brings senior scientists to JILA for a few weeks to a few months to collaborate with institute personnel and students.

JILA faculty, graduate students, and postdocs receive important national and international recognition for their work (at the rate of roughly an award a month, according to the self-study). In addition to the Nobel prizes, MacArthur fellowships and National Science Academy memberships already mentioned, a partial list of recent national and international awards includes: the American Physics Society (APS) Fellowship; the APS Davisson-Germer Prize; the APS Woman Physicist of the Month Award; the Arthur S. Fleming Award; the

Biermann Lectureship; the Boyle Medal; the Cottrell Scholars Award; the David and Lucille Packard Fellowship for Science and Engineering; the E. B. Bright Award; the Dudley Herschbach Prize for Experiment; the L'Oreal-UNESCO Award for Women in Science; the Maria Goeppert Mayer Award; the Marie Curie Postdoctoral Award; 24 National Research Council postdoctoral fellowships; the Pacesetter Award; the Presidential Early Career Award; the President's Committee on the National Medal of Science; and the Young Researchers Award. JILA also sponsors various workshops and conferences; e.g., the JILA Physics Frontier Center (PFC) recently held a three-day conference on cold temperature physics attended by over 70 scientists. JILA researchers invite summer researchers from universities that traditionally house underrepresented minority groups. Researchers have also represented JILA at national meetings such as the National Society of Black Physicists, the Conference for Undergraduate Women in Physics, and the National Society of Hispanic Physicists.

Analysis

The institute's main request in both the last and current review cycles is for improved space and research facilities. The external reviewers broadly supported this request, while the internal reviewers identified four problems in the self-study: First, the rationale for the requests was unclear, given that there is no plan to increase the number of JILA Fellows significantly. Second, there is some tension between renovating B-wing space to make it attractive to future recruits versus not fully completing renovation until the needs of future occupants are known. Third, conflicting answers were given to questions about when and how B-wing lab space should be renovated. Finally, neither the possibility nor the cost of fixing the electrical and heating, ventilation, and air conditioning outages in the B-wing was made clear. The external reviewers found the B-wing "terribly antiquated" and "well below the typical labs at competing institutions," predicting that it will simply fall into disuse unless renovated.

In its replies to the internal and external review committees, JILA argues that although lack of space is likely to make it more difficult to attract new faculty, immediate action is also "desperately" required for the research and retention of current faculty. Given the B and S wings age, failure to maintain necessary laboratory conditions could "with little warning become routine, with catastrophic results for research." In its reply, the institute identifies three assistance phases: First, in fiscal year (FY) 2018-2019, making detailed studies to identify problems with and solutions to heating, ventilation, and air conditioning and electrical issues. Second, in FY 2019-2021, completing the solutions identified in FY 2018-2019. Finally, in FY 2019-2021, replacing other building systems as necessary. It is apparent to ARPAC that there are multiple reasons for trying to address space and facility needs in a concerted way. These reasons include protecting current research results as

well as enabling future research efforts, maintaining safety, and enabling JILA to remain competitive in hiring and retaining prestigious faculty who could have state-of-the-art lab space at other institutions. ARPAC believes that the renovation of existing facilities generally should take priority over new space creation, especially as there is some prospect that a new H wing in the Duane Physics complex will be built. ARPAC suggests that JILA develop a more detailed plan concerning the relative priority of needs for renovation and new space. ARPAC strongly supports the first phase of renovation mentioned above, which involves more detailed studies to establish the most cost-effective means of modernizing older lab spaces with a minimum of interference to ongoing research.

Strategic Hiring Plan

The self-study and the internal reviewers note that several retirements are coming up, which is one reason that a detailed hiring plan might be useful. However, the plan's development faces three constraints: First, CU Boulder departments, not JILA, hire co-rostered JILA Fellows. Second, conversations between the internal reviewers and JILA members suggest that a more detailed plan could strain relations between the CU Boulder and National Institute of Standards and Technology sides of JILA, given their differing hiring processes. Finally, while the Office of the Vice Chancellor for Research and Innovation (RIO) might alleviate this asymmetry in hiring ability by rostering faculty in JILA, this might also threaten the longstanding commitment to collaboration between JILA and departments. As noted earlier, the self-study argues that it would inappropriate to commit in advance to a candidate belonging to a discipline, narrowly defined. According to the internal reviewers, these difficulties make the development of a more detailed plan "a longstanding issue, not easily resolved." This problem is only one instance of a more general problem on campus, namely, how to strike a proper balance among the

different teaching and research needs of departments, centers, and/or institutes when such units collaborate in hiring. The external reviewers argues that the institute's shared vision, goals, and collegiality make its flexible, opportunistic approach to hiring appropriate (perhaps more so than for other units on campus). Given both the difficulties outlined above and the institute's previous hiring success, ARPAC is inclined to agree with JILA and the external reviewers that there is no clearly demonstrated need for a more detailed hiring plan. Of course, this does not mean that JILA should not continue to consider its hiring needs steadily and carefully as time goes on.

Inclusive Excellence

Although it understands that JILA needs to be flexible in its hiring strategy, ARPAC would like to be assured that the institute is paying sufficient attention to inclusive excellence in its recruitment plans. With respect to climate, internal reviewers make three specific suggestions, with which ARPAC agrees: First, in response to a problem noted above, staff interviews should be conducted anonymously and on a regular basis by a third party and expanded to include all personnel. Second, in response to student requests, the institute should consider implementing a more formal mentorship program for students, postdoctoral fellows, and junior faculty. Finally, even though the self-study mentions several programs that already encourage scientific collaboration, JILA should consider providing more regular, formal scientific communication for students and postdoctoral fellows, such as a student seminar series. In addition to these internal reviewer suggestions, ARPAC suggests that it would be helpful for JILA to conduct a survey of postdoctoral fellows' attitudes about program satisfaction and climate, as well as to collect data about their job placement. Even more importantly, ARPAC believes that JILA should collect more information and try in a more systematic way to address issues about the representation of women and

members of underrepresented minority groups at every level of its organization. A first step in this direction would be to provide an inclusive excellence narrative.

Administration

The self-study claims that central scientific administration staff are overwhelmed by the rate of change in regulations and suggests that an administrative staff member be embedded in JILA. The external reviewers remark that all levels of the institute expressed similar concerns, and it suggests that campus administers improve their dialogue with JILA about current regulatory practices. It is suggested that central administration should discuss with JILA the implications of changes in rules and practices before those changes are implemented. The external reviewers also warn about using JILA as a test case for generally improving university administrative practices. ARPAC concurs with the external reviewers that more dialogue with central offices about the necessity of reducing administrative burdens is called for and that the campus should consider providing greater financial support to handling administrative policy, freeing up more time for research.

Fundraising

Although neither the self-study nor the internal reviewers discuss fundraising, the external reviewers recommends that the university hire a development officer to be housed in JILA and to report directly to the chair. According to the external reviewers, embedding a development officer in the institute could generate at least $2 million per year in new funds or contributions to endowment, and occasionally a large (>$20 million) commitment from a single donor. The argument for this strategy is that the need for alternative funding sources is just becoming apparent, that such internally directed efforts require several years to develop, and that all the elements needed for success are already present in the institute, including “scientific

stature, an engaged faculty, great ‘esprit de corps’ and a pre-existing outreach operation.” In the light of the institute’s expansive facility and space needs, ARPAC believes that JILA should explore such strategies for private philanthropy with the Office of Advancement, the deans, the vice chancellor for research and innovation, and with the provost. In this context, it should be kept in mind that RIO is expanding advancement capacity for the institutes.

Recommendations

The members of the Academic Review and Planning Advisory Committee (ARPAC) address the following recommendations to JILA, and to the offices of responsible administers. It is the committee's intention that the recommendations serve to benefit program improvement and development and to further the mission of the University of Colorado Boulder.

To the Unit:

1. Continue exploratory studies about modernizing older lab spaces in the most cost-effective way while minimizing interference to ongoing research.

2. Develop a more precise plan with respect to the priority of improving facilities relative to the need to create new space, again in ways that are cost-effective and non-disruptive.

3. Consider the external reviewers' suggestions for increasing private philanthropy to JILA as well as other strategies. Develop a specific plan for how such funds would be used.

4. Create an inclusive excellence narrative. Address in a systematic way issues about the representation and experience of members of minority groups and women at every level of JILA. Devise specific measures to increase the recruitment of underrepresented minority and women faculty, graduate students, post-docs, undergraduates and staff.

5. Appoint a third party to administer a staff climate survey and interviews anonymously. Expand to include all personnel on a regular basis.

6. Conduct a survey of postdoctoral fellows to ascertain their satisfaction with JILA and their views about climate and inclusivity.

To the Provost:

7. Work with member departments, the CU Boulder Office of Data Analytics, the National Institute of Standards and Technology, and JILA's internal records to collect information about job placement for JILA-based graduate students and postdoctoral fellows.

8. In coordination with member departments, implement a more formal graduate student mentoring program.

9. Increase regular, formal scientific communication for students and postdoctoral fellows, such as a student seminar series.

To the Vice Chancellor for Research and Innovation:

10. Work with JILA to fund exploratory studies to prioritize space requests. These studies should determine the most cost-effective means of modernizing older lab spaces and creating new spaces and facilities with a minimum of interference to ongoing research.

11. Work with JILA to develop strategies for increasing private philanthropy to JILA.

12. Support JILA in collecting information about representation and devising specific programs to improve the recruitment and experience of minority and women faculty, graduate students, postdoctoral fellows, and staff.

13. Request that the Office of Contracts and Grants and Sponsored Projects Accounting discuss with JILA ways of improving research administration.

14. Work with JILA in funding exploratory studies to determine the most cost-effective means of creating new facilities and

modernizing older lab spaces with a minimum of interference to ongoing research.

15. Work with JILA and the Office of Advancement in developing strategies for increasing private philanthropic giving to JILA, particularly to address space needs.

Required Follow-up

The chair of JILA shall report annually on the first of April for a period of three years following the year of the receipt of this report (i.e., April 1st of 2019, 2020, and 2021) to the vice chancellor for research and innovation and to the provost on the implementation of these recommendations. Likewise, the dean shall report annually on the first of May to the provost on the implementation of recommendations addressed to the college. The provost, as part of the review reforms, has agreed to respond annually to all outstanding matters under her/his purview arising from this review year. All official responses will be posted online.