



*Robert C. May*  
Telephone: (510) 987-0711  
Email: [robert.may@ucop.edu](mailto:robert.may@ucop.edu)

*Chair of the Assembly of the Academic Senate  
Faculty Representative to the Regents  
University of California  
1111 Franklin Street, 12th Floor  
Oakland, California 94607-5200*

June 3, 2019

**ARTHUR ELLIS, VICE PRESIDENT  
RESEARCH AND GRADUATE STUDIES**

**Re: Five-Year Review of the Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC)**

Dear Art:

At its May 22, 2019 meeting, the Academic Council approved the attached Five-Year Review of the UC Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC) Multicampus Research Unit (MRU). Following procedures outlined in the Compendium, the review was performed by a Joint Senate Review Committee, led by the University Committee on Research Policy (UCORP) with input from the University Committee on Planning and Budget (UCPB) and the Coordinating Committee on Graduate Affairs (CCGA).

The Joint Review Committee notes that since the mid-1990s, INPAC has supported the production of many successful multi-campus research projects and collaborations on nuclear and particle physics and experimental cosmology and astrophysics, among faculty, researchers, and graduate students on nine UC campuses and the three national labs. And while the individual members of INPAC continue to make great research contributions, there has been no UCOP or campus funding of INPAC since 2015; the INPAC Executive Committee has not met since 2016; and the MRU lacks a clear strategic plan for moving forward independent of UCOP financial support. The Joint Committee agrees that INPAC must reinvent itself to maintain influence and relevance. It recommends that INPAC stakeholders make a stronger, more tangible commitment to the MRU, and a stronger case for INPAC's continued MRU status; and that INPAC sponsor an all-hands meeting to consider whether and how to continue the MRU in the current financial circumstances.

The Academic Council appreciates the significant time and effort the Review Committee spent in preparing and writing this report. In particular, I want to recognize the substantial contributions and outstanding leadership of UCORP Chair Andrew Baird.

Please do not hesitate to contact me if you have additional questions.

Sincerely,



Robert C. May, Chair  
Academic Council

cc: Academic Council  
Senate Directors



UNIVERSITY COMMITTEE ON RESEARCH POLICY (UCORP)  
Andrew Baird, Chair  
Email: [anbaird@ucsd.edu](mailto:anbaird@ucsd.edu)

University of California  
Academic Senate  
1111 Franklin Street, 12th Fl.  
Oakland, California 94607

April 8, 2019

**ROBERT MAY**  
**CHAIR, ACADEMIC COUNCIL**

**RE: Five-Year MRU Reviews of UC Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC) and the UC Humanities Research Institute (UCHRI)**

Dear Robert,

On behalf of UCORP, CCGA, and UCPB, I am pleased to submit two five-year MRU reviews conducted by the committees this year. The UC Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC) and the UC Humanities Research Institute (UCHRI) were reviewed as specified by the Compendium, with UCORP as the lead committee and with the participation of members of UCPB and CCGA, who consulted with their respective committees.

UCORP would like to thank the staff of the Office of Research and Graduate Studies (ORGS) for their hard work and support leading up to and during the reviews.

Sincerely,

A handwritten signature in cursive script, appearing to read "A Baird".

Andrew Baird  
Chair, University Committee on Research Policy

cc: Kum-Kum Bhavnani, Academic Council Vice Chair  
Hilary Baxter, Academic Senate Director  
UCORP, UCPB, and CCGA members

Enclosures:

Review of Institute for Nuclear and Particle Astrophysics and Cosmology (pp. 2-15)  
UC Humanities Research Institute (pp. 16-24)

# Review of Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC)

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University Committee on Research Policy (UCORP)  
(Lead Committee)  
University Committee on Planning and Budget (UCPB)  
Coordinating Committee on Graduate Affairs (CCGA)

March 4, 2019

- I. EXECUTIVE SUMMARY, KEY FINDINGS AND RECOMMENDATIONS
- II. INTRODUCTION
  - A. History
  - B. Mission and scope
  - C. Service to University and State
  - D. Regional, National and International Visibility
  - E. Internal interactions between Units
  - F. External interactions
- III. EVIDENCE FOR ACCOMPLISHMENT
  - A. Research
  - B. Undergraduate education
  - C. Graduate education
  - D. Recognitions of Excellence
  - E. Public Service and Outreach
- IV. BUDGET
  - A. Materials provided for assessment
  - B. Profile of Expenses
  - C. Central Support
  - D. Local campus support
  - E. External support
  - F. Projected support
- V. ADMINISTRATIVE GOVERNANCE
  - A. Overview/Bylaws
  - B. Director
  - C. Personnel
  - D. Space and Resources
  - E. Contract and grant support
- VI. ADVISORY COMMITTEE(S)
  - A. Internal
  - B. External
- VII. CONCLUSIONS AND RECOMMENDATIONS

## I. EXECUTIVE SUMMARY, KEY FINDINGS AND PRIMARY RECOMMENDATIONS

*Summary:* Since its founding in the mid 1990s, the UC Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC) has served as a cornerstone for the advancement of research at the intersection of nuclear and particle physics, experimental cosmology and astrophysics, namely dark matter. It has involved researchers at all but one UC campuses and the UC-associated National Laboratories, not to mention the international research community. It has used local and central funding to play a key role in catalyzing new research and training and, by providing different core capacities, it has helped its members launch significant and extramural funding research projects.

*Findings:* In recent years, the loss of central support for INPAC-funded initiatives has added to the loss of contributions made from local campuses and a noteworthy absence of contributions from participating stakeholder investigators and their laboratories. Concomitant with the inability to identify, leverage or develop new sources for financial support, INPAC's activities have been significantly restricted and it appears that as a result, its influence – but not the influence of its individual stakeholder members – has waned. Compounded by the imminent retirement of INPAC's current Director, the lack of a clear and/or comprehensive plan for succession and the absence of a strategic plan to move forward, the future of this MRU seems dire, a finding that detracts from the significant enthusiasm for its potential.

*Recommendations:* In light of UCORP's review and the tremendous importance of both the research catalyzed by this MRU and its training of the next-generation of scientists and teachers, this review finds that INPAC must urgently re-invent itself to ensure its continued relevance. To this end, UCORP recommends that INPAC stakeholders sponsor a retreat for all members and stakeholders to assess the MRU's past, gauge its present and set a comprehensive plan for its future, including succession planning for the Director position. Details of this overarching recommendation are provided within. While UCORP considers the principle important that UCOP provide some financial commitment to the MRUs that it administers, such support is likely to be modest at best and likely unreliable. It therefore makes sense for INPAC to create a budget model that is independent of UCOP financial support.

## II. INTRODUCTION<sup>1</sup>

Research in the area of dark matter and dark energy has numerous facets that make the field unique. First it is highly collaborative in nature and crosses various disciplines from within astronomy, physics and engineering that are often involved in, and need, large scale international collaborations and facilities. The research also comprises theoretical, computational, observational, engineering, device and instrumentation development activities in different combinations, underscoring the need for an interface like INPAC. The continuous efforts in refining instrumentation and techniques push the extreme limits of what can be measured and result in technologies and technological improvements that find applications in many other fields. INPAC offers the opportunity to bring together researchers from across the spectrum of particle and nuclear physics and astronomy to enhance knowledge exchange and to solve one of the great mysteries of our universe. To this end, there can be measurable benchmarks that define the group rather than individual successes including manuscripts, white papers, position statements, patents and public presentations.

### II A. History

The Institute for Nuclear and Particle Astrophysics and Cosmology (INPAC) was founded in 1995 with an overall objective to promote collaborative basic research at the intersection of nuclear and particle physics, experimental cosmology and astrophysics. Since its founding, INPAC has been led by Professor Bernard Sadoulet, a world renowned scientist at UC Berkeley.

The central research focus of INPAC has been what is described as “the dark matter problem.” In brief, the motions of astronomical objects under gravitational interactions suggests that there is in fact much more matter in the universe than observed. While the nature of this material is unclear, there are a number of theoretical concepts to help understand what it might be, and how it functions, but they require collaborations between both particle physics and cosmology. With this in mind, INPAC was founded to serve as an umbrella to catalyze and hopefully coordinate work in this and related areas across the University of California campuses and the three National Laboratories under UC administration.

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<sup>1</sup>Findings discussed here are based on the analyses of INPACs 2017-2018 Annual Report, the 5-year Report and a telephonic interview with the INPAC Director in January 2019. INPAC does not have a web presence.

Given its founding goals, INPAC is ideally suited to the study of a number of core topics in particle physics, astrophysics, and cosmology.

## II B. Mission and scope:

The central objectives of INPAC remain to:

1. Improve the competitiveness of research initiatives within the University of California and National Laboratories in seeking funding
2. Coordinate funding
3. Facilitate graduate research
4. Forge connections with industry

## II C. Service

Consistent with the mandate of all UC MRUs to serve the research mission of the University, INPAC has tried to meet its responsibilities by increasing the regional, national and international visibility of its research into dark matter, stimulating internal interactions between UC campuses, and promoting external interactions. INPAC has had a mixed record in fulfilling collaboration and funding goals, but its members have clearly benefited from the collaborative interface INPAC has provided. In its attempts to attract federal funding, INPAC appears to have provided the university and the state with increased regional, national, and international visibility in an exciting research field. It has also sought to facilitate internal interactions between allied research groups within UC, many of which are themselves already highly distinguished and internationally visible.

## II D. Past, Current and Future Potential

There is significant unrealized potential in the INPAC MRU that merits close examination. In the past, INPAC has played a role in bringing together an otherwise fractious dark matter community and helped its members establish leadership in the field. By extension, the success of its members has meant that the nation, and not just the entire UC system, has reaped the benefits. In this regard, INPAC members have an impressive list of accomplishments. Together they provided technical input for the Deep Underground Science and Engineering Laboratory, convened a national Dark Matter Writing Group, coordinated research activities between UC campuses and LBNL and offered interdisciplinary training to each others' students. INPAC has completed a number of

successful projects using MRPI (Multicampus Research Programs and Initiative) funds, for example the development of a CTA (Cherenkov Telescope Array) prototype telescope.

### III. EVIDENCE OF ACCOMPLISHMENT

Since 2015, central funding of INPAC as an MRU has been nonexistent, in spite of the unquestioned success of its individual members and evidence for small funding at local sites. INPAC's annual and 5-year reports point to its past activities, like organizing a December 2014 Asilomar conference that focused on the connection of large scale structure and dark matter particle properties, as evidence of its service to its community. Such activities are clearly useful and help to fulfill the aims of the institute, but they are sporadic at best and there has not been much activity in the last five years. Better said, the activities have been commensurate with support. Yet the individual member researchers who constitute INPAC, many of whom are among the most distinguished researchers in their field, have been very successful in finding funding for group collaborations and individual research projects. Few if any of these stakeholders credit INPAC in publications or formally acknowledge INPAC's contribution to their success in their respective organizations while acknowledging the benefits of membership via their inclusion in annual reports and this 5-year renewal. The role played by INPAC in their research areas is not documented presumably because it is difficult to ascribe roles when the function is to catalyze collaborations at the interface of domains, rather than sponsor research per se.

While INPAC has built excellent faculty connections across UC as evidenced by documentation in the reports, the recent level of activities falls short of what one might expect given its inherent potential. Planning for proposed meetings and workshops and the exploration of various teaching and outreach initiatives are among the things the MRU should be doing and the handful of past activities is laudable. But given the status of being an MRU and the nature of the research involved in INPAC, a higher level of activity involving stable, ongoing collaborative projects with funding provided through INPAC participants and supported initiatives would be expected. Accordingly, INPAC indicates that it plans to hold a general meeting of members "soon." The main purpose of such a meeting should be self-reflective and directed towards whether, and precisely how, the MRU can (or should) serve the research interface on which it is founded.

### III A. Research

Astronomers, physicists and other scholars from 9 UC campuses with relevant programs and the UC-managed National Laboratories have been associated with INPAC and have demonstrated enormous individual research productivity over the course of the review period. The often multi-disciplinary and international research projects, which are driven by the desire to understand the nature and properties of dark matter and dark energy, have resulted in hundreds of peer-reviewed publications. The importance of the work of these researchers is evidenced by numerous citations of their publications, the extensive extramural funding of their projects, the significant amounts of project funding they receive and, last but not least, the worldwide press and recognition that some of this work received. The contribution of INPAC as a MRU meant to catalyze this success, however, is less documented.

INPAC reports roughly 850 scientific publications receiving 10 or more citations in the 12-year period between 2006 and 2018, which extends significantly beyond the five years under assessment here. These publications are reported to be the result of 26 major projects and general research efforts and are a mix of articles, book chapters and conference proceedings with and without peer review. Notably, the two most highly cited publications involving INPAC members – with 3403 and 1569 citations received since 2016 – are from work that led to the 2016 Nobel Prize in Physics for the experimental discovery of gravitational waves. This number of publications constitutes a significant scientific output, and, with over 50,000 citations, these publications show strong impact. However, as the report points out, INPAC cannot claim that the results are a (direct) consequence of INPAC's work. Authors do not identify themselves as members of INPAC in these publications and INPAC is an organization that seeks to facilitate collaboration, not sponsor research.

Individual members of INPAC have been receiving significant amounts of research funding from federal funding agencies, through large scale national and international projects that are typically restricted to specific projects rather than overarching missions at the interface of disciplines. INPAC, however, reports that it has contributed to the success of individual funding efforts by providing leadership and technical guidance for projects such as for the Deep Underground Science and Engineering Laboratory, the next generation worldwide ground-based gamma-ray observatory (CTA), and two "Generation-2 dark matter



experiments,” called SuperCDMS and LZ. Documentation of this contribution could be available in participant testimonials but are not included in the 5-year report.

INPAC has sought central funding through the MRPI initiative and was partially MRPI-funded from 2009-2015 under the “UC Dark Matter Search Initiative-MRPI.” These funds are described as instrumental to enable R&D across the UC system and members’ success in obtaining funding for SuperComs, LZ and a CTA prototype telescope. Furthermore, MRPI funds supported several of INPAC’s postdoctoral scholars.

As part of its major mission to bring together the various scholars working on different flavors of dark matter research, INPAC reports to have facilitated workshops, writing groups, conferences and summer schools. These efforts by INPAC have had broad impacts in terms of initiating new scientific projects and providing leadership in the community but have waned with lack of central funding in the last five years. In 2013, a roadmap generated by the national Dark Matter Writing Group was adopted as operational language. In 2015, an undergraduate symposium on neutrino physics led to new collaborative efforts by individual members. Within the UC system the synergizing efforts catalyzed by INPAC are described as instrumental in the initiation of new collaborative research. INPAC describes itself as “tying together theory efforts in fundamental dark matter particle production mechanisms in the early universe and the properties of these particles with UC’s world-leading effort in observational astronomy.”

Overall these advances constitute a monumental accomplishment considering the numerous researchers from across the UC system and from diverse fields that tend to have very different research cultures. In its existence, INPAC has involved 136 senior researchers (faculty & senior national lab staff), nearly 50 postdoctoral researchers, 40 graduate students and 32 undergraduate students from 32 subfields and large-scale projects in the general areas of Dark Matter Experiments, Cosmic Microwave Background, Dark Matter/Dark Energy, Neutrino Experiments, Gamma Ray Astrophysics, Neutrinos/Cosmic Rays/Indirect DM, and Theoretical Efforts.

### III B. Undergraduate and Graduate education

INPAC reports that a large part of its mission has been to contribute to graduate education. It lists 32 undergraduates in addition to 40 graduate students who have participated directly in various science projects conducted/led by researchers affiliated with INPAC. It

is presumed that through their participation in individual research projects as well as INPAC-organized workshops and conferences (e.g., at Asilomar), these students have the unique INPAC-dependent opportunity to get to know the collaborative, multi-disciplinary and international aspects of the research of other INPAC members at the interface of disciplines. Furthermore, through starting to involve undergraduate students from the Merced campus, a minority serving institution, INPAC is demonstrating commitment to broaden participation of students from non-traditional backgrounds.

### III C. Post-doctoral Scholar Career Development

INPAC reports that it has provided nearly 50 post-doctoral scholars with opportunities to shape their careers in ways that depend on the support of research at the interface of disciplines. Several of these postdocs are said to now hold faculty research positions at universities including UC and as staff scientists in the National Labs. This accomplishment speaks to the quality of the research of INPAC members.

### III D. Recognitions of Excellence

Through the large number of research teams and their accomplishments, the individual efforts that are coordinated by INPAC appear to be widely recognized in the community. Direct recognition of INPAC's work is evidenced, for example, with successfully funded projects and the adoption of INPAC-coordinated positions like the National Dark Matter Writing Group as the operating language in the community. Generally, however, INPAC appears to go uncredited for new collaborations, research projects, manuscripts and funding by members that interact under its aegis. Evidence for INPAC's mission as a catalyst, not an intermediary, of research funding would be strengthened by member testimonials, citations in papers or more formal affiliations.

### III E. Public Service and Outreach

With the exception of inclusion efforts of the 2014 INPAC General Meeting to increase the number of students from non-traditional backgrounds in nuclear and particle physics and astronomy, there is little evidence that INPAC has explored increased public service and outreach. This is likely ascribed to the lack of any direct central funding to support this aspect of the MRU's mission. Public service and outreach efforts could have benefited from more active member engagement at the local sites on UC campuses and the National Laboratories.

#### IV. BUDGET

The INPAC MRU currently receives no central funding, although it has had past success in competing for MRPI funding from UCOP. For this reason, it currently exists as an aspirational umbrella to support ongoing work by its individual members. INPAC intends to sponsor meetings to exchange ideas, introduce students and serve as the interface of fields that are normally isolated. To that end it describes aspirations to raise funds but offers no specific plan. Local campuses provide some support for members but do not “buy time” for dedicated efforts and commitments. Fund raising efforts are also undermined by a combination of a lack of strategic planning, an uncertain future due to the pending retirement of the current director, and the lack of dues or matching funds from its members to support INPAC’s mission. Together these point to lack of tangible engagement in INPAC by its membership.

## V. ADMINISTRATIVE GOVERNANCE

INPAC currently functions as a network of collaborating investigators. Accordingly, it is designed to operate as an umbrella that fosters research in areas that intersect rather than overlap with its diverse membership. Membership is governed by a Director and Executive Committee that are meant to work together to leverage local research resources and talent. To the knowledge of this review group, INPAC does not have any written bylaws but would likely benefit from following the best practices guidance provided by UCOP's Office of Research and Graduate Studies<sup>2</sup> to govern its formal operations. The bylaws would establish processes, formalize the identity, roles and responsibilities of the Executive Committee, establish mechanism(s) for communicating with UCOP, help with organizing the preparation of reports and coordinate the solicitation of future funding. The bylaws would also provide for formal process for selecting Executive Committee members from UC campuses and national laboratories as well as developing strategic planning for things like the pending leadership succession.

### V A. Director

The INPAC Executive Committee nominates the Director who is then appointed by the UC Provost. The Director reports to the UC President locally through the campus Vice Chancellor for Research (currently UC Berkeley) and centrally through the UC Vice President for Research and Graduate Studies. The current Director of INPAC is Professor Bernard Sadoulet at UC Berkeley who is highly qualified and world renowned but reported to UCORP that he will retire from teaching in 2019. A leadership transition plan is currently under development.

### V B. Executive Committee

The INPAC Executive Committee is meant to provide governance and help the Director set scientific directions and policies for its members, and help sponsor and organize workshops. It is currently composed of 19 members selected from the 9 participating campuses and 3 national laboratories. It is reported to hold three teleconference meetings per year.

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<sup>2</sup> <https://www.ucop.edu/research-initiatives/programs/mru/other-guidance.html>

#### V C. Space and Resources

As an umbrella, INPAC has no formal operating space. Each INPAC faculty member including the Director has his/her own campus-specific assigned areas and research space, which in some cases includes specialized laboratory facilities.

#### V D. Personnel

There are no INPAC personnel per se and the INPAC umbrella organization currently operates without dedicated staff, funding or resources.

#### V E. Contract and grant administration

There are no current INPAC contracts or grants. The administration of contracts and grants is handled in separate centers and departments on each of the nine INPAC campuses.

## VI. Advisory Committees

Formally, INPAC is described as governed by an Executive Committee (EC) that is responsible for defining INPAC's scientific directions and broad policies. The EC meets three times a year with 1-3 representatives from each institution, and appears to enjoy strong engagement from each campus. While there has been an organized meeting at Asilomar and participation of faculty on advisory committees, there appears to be no formal external group that the EC can consult for input.

## VII. CONCLUSIONS AND RECOMMENDATIONS

This review concludes that the INPAC MRU has played a unique and critically important role in dark matter research. Its members have made valuable contributions to research, education, and mentoring. The significance of this MRU's work has also extended well beyond any one UC campus, the UC system or even the nation. Ironically however, it is the scope of the individual accomplishments of its members to their field(s) that is the most impressive component of this MRU. The contributions of INPAC as an MRU to catalyze members' individual success appears poorly documented; while they are described as (1) having been brought together by the MRU and (2) clearly advanced knowledge in areas that could never have been predicted, let alone imagined, the MRU has stayed in the background. Individual stakeholders rarely cite or acknowledge the MRU in any form and as a result INPAC has not been successful in branding its organization and leveraging its significant past funding for continued cross- and interdisciplinary research programs. This needs to be rectified for the MRU to flourish.

This review finds that in light of the current director's imminent retirement, INPAC must re-invent itself to ensure its continued influence in the field. The Review Committee recommends that INPAC stakeholders demonstrate a tangible commitment to the MRU by developing a comprehensive plan for its future. The Review Committee suggests a full day retreat devoted to strategic and budgetary planning that would be sponsored by members/stakeholders. The retreat would allow members and stakeholders to (1) assess their past, (2) gauge their present, and (3) set a comprehensive plan for the future. While UCORP considers it important that UCOP provide some financial commitment to the MRU, such support is likely to be modest. INPAC's budget model should be independent of UCOP financial support.

The strategic planning exercise should include:

- (1) The establishment of bylaws to better define and/or update
  - a. Mission
  - b. Organizational processes and framework
  - c. Governance (composition of executive or advisory board, establishment of a scientific board, member participation)
- (2) Succession plans and processes for appointment of a new director
- (3) The development of a sustainable funding plan that would support current and projected infrastructure and operational needs. Elements might include:

- a. UC central and “local” campus support
  - b. Collaborating institutional support from National Laboratories
  - c. Taxation of successful initiatives
  - d. New extramural federal support
  - e. New philanthropy and charity support
  - f. New sources through UC Sacramento and UC-DC
  - g. Direct support from participating stakeholders and their laboratories
- (4) Creation of an outreach plan to
- a. Highlight the MRU's contributions to UC's core scientific mission
  - b. Develop and maintain a web presence
  - c. Ensure the acknowledgment of INPAC in stakeholder position statements (white papers), funding proposals, progress reports, reviews and publications.

Despite of the broad list of stakeholders who appear to participate in this MRU, it is possible that not all feel that the MRU merits their direct (time) or warrants their tangible (financial resources) engagement. The recommended strategic planning exercise should therefore include a discussion of disestablishment of the MRU. If it cannot serve its goals going forward, then perhaps it does not make sense for the institute to continue.