Comisión Nacional de Investigación
Científica y Tecnológica - CONICYT

ASSOCIATIVE RESEARCH PROGRAM
SUPPORT TO SCIENTIFIC AND TECHNOLOGICAL CENTERS OF EXCELLENCE WITH BASAL FUNDS
ANNUAL EVALUATION

GUIDELINES

This evaluation is an almost free format one, although it has to consider the main objectives of Basal Funds for Research Centers of Excellence which in general terms is to perform Research and research -related activities (publications, dissemination to academic sectors through workshops, symposia, etc., young researchers formation, student training, aid to smaller research groups) but also to actively provide other sectors (mainly industries and enterprises but also public services) their knowledge and resulting products in order to contribute to the country development as well as keep the society informed on their advances.
The sections below will guide you to express your expert opinion in each of these aspects. These Centers are been financed by public and private funds following the same strict rules of Basal funding. Their main source of public funds is provided from this Program and has an extension of three years.

PRESENTATION (To be completed by the Program)
REPORT PERIOD : 1ST Year X 2ND Year □ 3RD Year □
PERIOD COVERED : From May 2018 to February 2019

NAME OF THE CENTER	CODE
CENTER FOR ASTROPHYSICS AND ASSOCIATED TECHNOLOGIES	AFB170002
DIRECTOR OF THE CENTER	SIGNATURE
MARIA TERESA RUIZ	
EXECUTIVE / DEPUTY / CO-DIRECTOR	
GUIDO GARAY	
MANAGER (if applicable)	SIGNATURE
SPONSORING INSTITUTION (if applicable)	
UNIVERSIDAD DE CHILE	
ASSOCIATED INSTITUTION(S) (if applicable)	
PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE, UNIVERSIDAD DE CONCEPCIÓN	
CENTER WEBSITE ADDRESS	
WWW.cata.cl	

I. MAIN ACADEMIC-SCIENTIFIC CONTENTS OF THE REPORTING PERIOD

Please provide information related to the following sections taking into account the written report, the indicators that the same proponents gave for their follow-up (Table 2-indicators) and some information on productivity of the latest period that the Program is sending or accessing to:

https://www.dropbox.com/sh/alzf7c3x4gc1mux/AAD8371Ps5LIsuo_NllTfHZDa?dl=0

1) Research advances and relevance, student training and collaboration to other research groups.

Considering the objectives established as fundamental for these Centers: give your opinion upon the advance in research lines and activities, national and international scope of the science developed and impact on the corresponding disciplines from a global point of view. Include here your perception on influence/impact that this research has had on young scientist´s generation and smaller national research groups if any.

The main expressed goals for CATA are to promote and carry out research to elucidate the origin and evolution of celestial objects, educate the next generation of Chilean astronomers and to train new engineers and technicians through development and operation of astronomical instrumentation through technological innovation. Evidence from the progress reports provides an excellent case that CATA is succeeding in all three efforts:
Research: The primary intent for CATA is to allow Chilean researchers to be engaged in the world-leading astrophysical facilities that are in-country but built and supported by international collaborations. The facilities allow Center members to do research to understand the formation and growth of supermassive black holes, galaxy formation and evolution, understand the stellar populations in the Milky Way, better refine the extragalactic distance scale, and explore planet and star formation. This work, in turn, enables the work of the next three years to continue exploitation of next-generation instruments (ALMA, LSST and GMT) for the new capabilities they enable. The examples given are for work in detecting proto-galaxies at extremely high redshifts, studying the formation of proto-stars and the evolution of proto-planetary disks. CATA members are collaborating on the most scientifically valuable instruments and with the best collaborations available for astronomical science, especially but not exclusively, on ALMA, VLTI, and CTA. A necessary part of these explorations is planning for use of the future instruments which will be available in Chile and so Center members are engaged in mission planning for LSST, a new instrument for the ESO VLT, and planning for exploitation of future data releases of ESO's VVVX, NGTS and ALMA. The science projects and collaboration ties are world-class and represent a great return on past investment in CATA by Chile. Particular highlights are the publication of four K2 planets in 2018, development of a methodology to improve galactic distance measurements and agreements that will allow the CTA-South array to be built and operated at the ESO Paranal site.

Educating Human Resources: Developing the scientific and technical workforce to carry out the research described above is time-intensive as it involves years of educational training to develop new researchers, engagement in instrument development and exploitation projects which require competing against groups at world-class institutions and creation of sufficient computational expertise and procurement of computing power (calculation and storage) to match facilities available to researchers in other nations.
The proposal now cites about 60 astronomers working at Chilean institutions. The proposal lists the next three years of the extension period as essential to increasing that number to take full advantage of the 10% of observing time available for Chilean researchers at the in-country observatories. A specific number of 25 new Assistant Professors is ambitious. At this level the country would have a significant presence in the international collaborations working at ALMA, LSST and GMT. The plan to have part of this increase be through hiring faculty with expertise in astrophysical instrumentation is laudable but difficult to achieve. The proposal rightly identifies the current number of researchers as too small, so the motivation to address this is very high. If approved for the extension, CATA management is encouraged to consider that increasing diversity at all levels of academic training and research (i.e. undergraduate through Assistant Professor), particularly gender diversity, should remain a very high priority.

Considerable expertise has been built up in high performance computing and simulations. It is notable that CATA has responsibility to operate the observational databases of both the ATLAS and VVV surveys. Developing multi-wavelength capability positions Chilean researchers to be at the forefront of multi-messenger astronomy in the future. The fact that researchers at other Chilean institutions are brought in on this activity is laudable.

Astronomical Instrumentation: Past successes include the build-up of astronomical instrumentation groups in each of the associated universities. This is a major achievement that has resulted in the production of systems for ALMA and improvements in digital signal processing for sideband separation and polarization detection, production of heterodyne array cameras, development of characterization systems for large antennas and work on terahertz photonics. The first of these is the most important as global competition to build the next phases of ALMA upgrades was fierce. Production of Band 1 optical systems and production of optics for Band 2 and 3 prototypes represents trust by the international community in Chilean technical capabilities. Related work has also been useful for possible impact in technical innovation that could lead to significant technology transfer to Chilean industries.

2) Pathways of students that have been part of the Center.

Give your insight on the pathways of students that have been part of the Center but that are not engaged to it anymore because they migrated to other working sources or to continue their training.

The existing and proposed opportunities for undergraduate and graduate students and postdoctoral scholars is again, world-class, in that the opportunity to work directly with observatories in Chile is a rare opportunity for students from other countries. The chance to publish is also being fully exploited by students at CATA and the success of the endeavor is reflected in the successful post-CATA appointments, i.e. graduate

schools, postdoctoral appointments and faculty positions, reported for past members. The production of PhD students (8 in 2018) is modest for 3 institutions but the number of postdoctoral fellows indicates high interest in the scientific program for CATA. The continuation of scholarly work in the field (more than 90% of Masters and PhD students) indicates that the scientific training of the students is excellent. The list of institutions to which they have been accepted is impressive.

Specific recommendations here are:

1. Increase the number of postdoctoral opportunities. Dealing with teaching loads while maintaining sufficient overview and training of graduate students and increasing opportunities for undergraduates to engage in research mandates use of postdoctoral scholars. The list of projects already undertaken by CATA should be sufficient to attract a stellar group of young researchers.
2. Find a way to allow for more extensive travel and remote research opportunities. There is little substitute for actually working side-by-side with colleagues from other nations for extended periods of time (weeks to months). The inherently international nature of astrophysics research means that lack of opportunity for researchers and even technicians to work in this way decreases the effectiveness of the local effort.
3. Increased effort on improving gender diversity of the faculty attached to CATA should be a top priority. This involves long-term efforts to improve the diversity of the astrophysics pipeline in Chile. This requires extensive outreach to elementary school students but sustained support through introduction of cutting-edge science into the undergraduate curriculum, more opportunities for students to engage in research, mitigation of the effects of implicit bias in the classroom and laboratory and additional supports for women entering scientific work to deal with sometimes hostile environments.

II. MAIN ACHIEVEMENTS IN KNOWLEDGE AND TECHNOLOGY TRANSFER

(APPLICATION OF THE RESEARCH RESULTS INTO ACTIONS THAT CONTRIBUTE TO INCREMENT THE COMPETITIVENESS OF CHILEAN ECONOMY (INDUSTRY, CIVIL SOCIETY AND PUBLIC BODIES OR POLICY MAKERS)

Please evaluate in this section whether the Center is taking the appropriate steps in developing applicable research results, managing their intellectual and industrial property, approaching to the adequate public and/or private entities that may use or be interested in using these results and in general doing it in the correct way. Is there an impact expected from the developments and initiatives?

The general means of transferring knowledge gained from scientific endeavors is through peer-reviewed publishing. CATA lists over 700 ISI publications in the last two years for 10 principal investigators. This compares favorably to highly-ranked astronomy groups throughout the world. The development of intellectual property for astronomical instrumentation has come a long way since the beginning of CATA. The production of optical systems for ALMA is a highly-appropriate use of the proximity of a major astronomical instrument. Critical design reviews indicate that the CATA work is being recognized as equivalent to the results of top tier institutions throughout the world who compete for these production projects. The FPGA-based digital signal processing

project holds promise but awaits larger scale adaptation by the community. Development of other radio wavelength components justifies a belief that the Center's developments are competitive in the research marketplace.

Whether the work to improve the competitiveness of the Chilean economy will succeed remains an open question. Four tech transfer inventions were described. Two may find broad use while a third remains in the realm of extending scientific research (in biology) and a fourth is still to be demonstrated to the mining industry in 2019. Establishing economic impact from work stemming from fundamental research is notoriously difficult. Chilean universities also are just developing means for commercializing research results which are as effective as those in some other countries like the US. The listed innovations here represent a good attempt, but the most likely high impact activity is the training of engineers and technicians who develop skills and knowledge by researching, developing and producing cutting-edge instrumentation for next generation astronomical observatories.

III. OUTREACH RESULTS AND IMPACT

In this section evaluate the efforts of the Center to disseminate its activities /results to the society in general. Do you think it has succeeded in giving relevance to its scientific outcomes? Was it able to transmit the importance of science in the life of the common individual? Have they been able to focus in their strengths to obtain the best of the outreach units and activities?

CATA has had notable success in extending its reach to the public through social media. The website is excellent. Podcasts, public lectures and exhibitions appear to have reached tens of thousands of Chilean citizens per year. There is an increasing rate of news media pick-up of stories generated by discoveries involving Center members. Given the excitement of science to come soon, it is likely that these numbers will all increase in the next 3 year period. This is all good. Measuring impact though is something that is formalized and should be conducted by researchers experienced in determining public engagement and public understanding of science. The report and proposal do not talk specifically about how this assessment is being done but, at the current level, it should be included as part of the outreach budget that evaluation be included for all public events and social media outlets. This goes beyond just numbers of visits and retweets to look at understanding, appreciation, and the likelihood of continuing interest, particularly among younger members of society. As an example, the proposal specifically mentions activities like using portable telescopes to go out to school communities and introduce them to the night sky. This is likely to stimulate interest but without follow-up activity to measure the impact in terms of sustained interest in and appreciation of science it is difficult to understand just how to compare this to other potentially impactful outreach activities.

IV. PARTICIPATION OF COUNTERPART FUNDS

The Center has completed a Financial Statement of the sources that have allowed it to perform its activities over this period.

Please give your opinion whether you think the balance between public and private funds is appropriate. In particular take a look at the Counterpart Funding and indicate if the progress in funds obtained in the period are reasonable for the progress of the activities planned and the intrinsic requirements of the funding.

The balance of public and private funds looks appropriate given the state of technology transfer at this point. Monies are being effectively used to support human capital development and participation in global collaborations which make use of facilities placed in Chile. This is basic research and hence the fraction of money obtained from public sources is expected to be quite high. I find the ratio described here to be quite appropriate.

Overall, the main recommendation for the project is that attention to building the next generation of Chilean astronomers, engineers and technicians is paramount, particularly with respect to diversity. Of secondary, but still necessary, concern is to measure the impact of various outreach activities. This requires professional help which should be allocated for with appropriate financial support.
