BASAL FINANCING PROGRAM
FOR SCIENTIFIC AND TECHNOLOGICAL CENTERS OF EXCELLENCE

ANNUAL PROGRESS REPORT

GUIDELINES

The report should be written following the format specified hereafter. Once it is completed, it should be sent in printed and in electronic version to the following address:

Programa Financiamiento Basal
para Centros Científicos y Tecnológicos de Excelencia

CONICYT
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REPORT PERIOD : 1st Year ☐ 2nd Year X 3rd Year ☐ 4th Year ☐

PERIOD COVERED : From January to December 2009

I. PRESENTATION

NAME OF THE CENTER	CODE
CATA: Centro de Astrofísica y Tecnologías Afines	PFB-06
DIRECTOR OF THE CENTER	**E-MAIL**
María Teresa Ruiz	
EXECUTIVE / DEPUTY / CO-DIRECTOR	
Guido Garay	
MANAGER (if applicable)	
SPONSORING INSTITUTION (if applicable)	
Universidad de Chile	
ASSOCIATED INSTITUTION(S) (if applicable)	
Pontificia Universidad Católica, Universidad de Concepción	
CENTER WEBSITE ADDRESS[1]	
www.cata.cl	

[1] The home page of the website should contain the logo of the Basal Financing Program and of CONICYT.

I, as Director of the Scientific and Technological Center of Excellence and in line with the obligations stated in Clause 17th of the Grant Agreement, declare that:

- The attached report represents an accurate description of the work carried out by the Center during this report period;
- The Center (tick as appropriate):

  X has fully achieved its objectives for the period;

  ☐ has achieved most of its objectives for the period with relatively minor deviations[2];

  ☐ has failed to achieve critical objectives and/or is not on schedule[2].

Signature Director _____ Date 10 / 05 / 2010

2 If either of these boxes is ticked, the report should reflect this and any remedial actions taken.

Research Lines

N°	Title	Objective	Principal Investigator	Other Investigator
1.-	Area 1	Birth and evolution of structures in the Universe	Leopoldo Infante	Barrientos, Bauer, Cuadra, Escala, Galaz, Lira, Lopez, Nagar, Padilla, Quintana, Reisenegger
	Area 2	Stellar Populations in the Local Universe	Doug Geisler	Catelan, Costa, Jordan, Mendez, Richtler, Rubio, Zoccali
	Area 3	Distance Scale	Wolfgang Gieren	Costa, Hamuy, Mennickent, Minniti
	Area 4	Star Formation	Guido Garay	Bronfman, Casassus, Escala, Mardones, May, Rubio
	Area 5	Extrasolar planets and brown dwarfs	Dante Minniti	Jordan, Mendez, Rojo, Ruiz
	Area 6	Supernovae and Dark Matter	Mario Hamuy	Clocchiatti, Maza, Reisenegger
2.-	Area 7	Astronomical Instrumentation	Leonardo Bronfman	Altamirano, Bustos, May, Mena, Nagar, Vanzi
	Area 8	High Performance Astronomical Computing	Alejandro Clocchiatti	Cuadra, Escala, Padilla
	Area 9	Outreach	José Maza	Galaz, Nagar

Changes in research personnel

Indicate any changes in the Staff of Principal Investigators and other Investigators as compared to the original Development Plan.

No changes in the staff of Principal Investigators.

Advisory Committee

Name its members and date of constitution, describe its task(s), frequency of meetings, decisions taken and/or recommendations made. Attach reports, if applicable.

The Advisory Committee of the CATA was created during 2009. The Committee is constituted by four distinguished scientists with experience in the direction and/or scientific operation of International Institutes or Observatories:

- Dr. Mark Phillips, Associate Director, Carnegie Observatories (Chair)
- Dr. Tom Wilson, Senior Scientist ALMA-Project
- Dr. Lars Nyman, Head of Science Operations, ALMA
- Dr. Rainer Mauersberger, Commissioning Scientist, Joint ALMA Office.

During November, 2009 the Advisory Committee visited Cerro Calán and reviewed the operation of the Center since its creation, meeting independently with researchers, postdoctoral fellows and students. After the on site visit, the Advisory Committee handled the Center Director a document with a critical view of the Center and recommendations. The document is appended to this report.

II. EXECUTIVE SUMMARY OF THE PROGRESS MADE

This section should be written in no more than two pages (Arial 10 or equivalent) and must be in relation to the progress made in the reporting period. This information is public and may be published on CONICYT's web site.

The Centro de Astrofísica y Tecnologías Afines (CATA) is hosted by the Universidad de Chile at its Astronomy Department in Cerro Calán, and has as associated organizations the Astronomy Department of the Pontificia Universidad Católica and the Astronomy Department of the Universidad de Concepción. The main goals of the CATA are to produce a significant increase in the astronomical community working in Chile: researchers, students and specialized engineers, in order to meet, in the best possible way, the challenges posed by the newly available facilities and take advantage of the opportunity for technological developments associated with these foreign investments. One of the goals of CATA is to support Chilean astronomers and engineers to become actively involved in the joint development of new instrumentation, which requires innovation in high technology and computer science. The actions taken by the CATA during its second year of operation have been very successful in pursuing these goals.

CATA has brought forth a substantial increase in the number of new researchers at the three associated institutions. During the second year of operation, CATA hired four astronomers: Franz Bauer, Jorge Cuadra, Ricardo Demarco and Michael Fellhauer, and one engineer: Pablo Altamirano on a full-time basis. This brings to nine the total number of new researchers incorporated to the Center. The research interests of Bauer include: AGN demographics, feeding, and evolution; the coeval growth of galaxies and super-massive black holes; deep blank-field multi-wavelength surveys, structure formation and galaxy cluster evolution; and nearby supernovae and X-ray binaries. The research interests of Cuadra include the studies of gas and stellar dynamics in galactic nuclei. In particular, he is interested in the origin of the puzzling young stars in the Galactic Centre and in the merger of massive black hole binaries in a gaseous environment. Demarco specializes in studies of large scale structures and in studies of the formation, evolution and dynamics of cluster of galaxies. The research interests of Fellhauer include the formation of star clusters out of star-forming sub-clumps, numerical simulations on the role of proto-stellar winds in the formation process of star clusters and on the formation of dwarf spheroidal galaxies inside a dark matter halo. Altamirano is an expert on the design and construction of radio and mm receivers and he will work at the Millimeter Wave Laboratory as Manager of the ALMA Band 1 Prototype Receiver Project. We also recall that during its first year of operation, CATA incorporated into the research and academic activities of the Center twenty new scientists at the different institutions on a partial time-basis.

CATA is supporting the formation of human resources in astrophysics in all of the Astronomy programs in the country, which were created due to the efforts of Center members. The number of graduate astronomy students at the three institutions associated to the Center has experienced a ten fold increase with respect to the average value of the last decade, with currently a total of 64 students. Most of these students have benefited from the Center by receiving grants in order to participate in observing runs at the International Observatories in Chile and/or to attend international meetings. In addition the Center has given full fellowships to several graduate students. The Center has hosted several scientists from abroad. Their expertise on different astrophysical topics has enhanced the activities of the Center. In addition to the research collaborations with Center members, the visiting scientists have played an important role in the teaching of astrophysics in our Ph.D. programs. CATA is also supporting the hiring of postdoctoral fellows, which are expected to be key elements in establishing strong scientific collaborations between all associated astronomical Institutions. During the second year of operation CATA allowed the hiring of two new Postdoctoral fellows.

CATA is strongly promoting and fostering collaborations among astronomers working in related topics across the country, as well as internationally. In particular, CATA is encouraging scientists from the three Chilean institutions to work together in large collaborative projects that are beyond the scope of small research groups. Key programs have been already implemented and granted considerable amounts of observing time in several telescopes at the International Observatories in Chile. These

large, as well as small more individual, projects are providing a strong start to fulfil one of the goals of the Center, namely to broaden the research base in each astronomy site within the country. They have been granted considerable amounts of observing time in several telescopes at the International Observatories in Chile.
The scientific work performed in all six research areas of the CATA during the second year of operation has been considerable. During the period January 09 - December 09, CATA members published one hundred and nine (109) papers in refereed journals. Collaborative work among Center members continues to increase, ensuring the fulfilment of one of the scientific goals of the Center which is to boost strong scientific collaborations between members of the different participant institutions.

During 2009 CATA continued to play a key role in the development of high technology in Chile. The initiatives in astronomical instrumentation, high performance astronomical computing and robotics are moving successfully and as expected in order to achieve their final goals. All these projects are involving professors of electrical engineering and engineering students from the associated institutions. We expect that at the end of the ten year period, CATA will not only be responsible for the production of high technology astronomical products, but also the seed for the development of engineering and industry in the country.

In summary, activities in both the research and development of high technology areas have started in-full.

III. OBJECTIVES AND RESULTS ACHIEVED

Considering the objectives established in the Annual Operation Plan (POA), in no more than *fifteen* pages describe the results achieved during the period. Refer also to those objectives that have not been accomplished indicating the reasons.

1.- Scientific and technological research of excellence with national and international scope and collaboration.

The scientific contributions from the members of the Center for Astrophysics and Associated Technologies (CATA) during its second year of operation are fully in accord with the science goals as formulated in the original proposal. One hundred and nine (109) papers have been published in refereed journals during year 2009. The list of refereed (ISI) publications is presented in the enclosed Table. Given the amount of publications, it is not possible to give a complete and exhaustive view of all the research carried out during the past year. In summary, research activities in all areas proceeded intensely in-line with the initial science objectives and broadening their scope. A summary of the principal science results obtained during the second year of activities in each of the individual areas of research is presented in what follows.

Area 1: Birth and evolution of structures in the universe (P.I. L. Infante)

The long-term aim of Area 1 is to contribute in the understanding of the nature and evolution of large scale structures in the universe. Astronomers at CATA are developing ambitious research programs, both observationally in the form of large surveys and by studying individual objects at different look-back times and theoretically by carrying out large cosmological simulations. We are preparing ourselves to take advantage of the new telescopes and instruments that will soon be available to Chilean astronomers, such as ACT, VST, VISTA and ALMA, as well as those that will be available in the near future, such as the GMT, LSST and the E-ELT. Our plans are to develop unique surveys and large theoretical simulations lead by scientists in Chilean institutions. In what follows we mention the most relevant activities carried out and preliminary results produced during 2009.

1. Surveys.

ACT Survey. The Atacama Cosmology Telescope (ACT) is a millimeter instrument that is expected to observe a large fraction of the southern sky at millimeter wavelengths, allowing for high-precision measurements of the CMB anisotropies power spectrum and for the detection (by their Sunyaev-Zel'dovich signature) of a large sample of galaxy clusters. A large collaboration between ACT and Center members has been established. The most notable contributions, made during 2009, are: (1) The first detections of galaxy clusters in the ACT southern hemisphere maps, in addition to the detection and photometry of the millimeter galaxies (radio and "SCUBA" galaxies); (2) The launch of a deep-30 square degree survey of southern sky with the Atacama Cosmology Telescope, which maps simultaneously in three millimeter bands (148, 225 and 280 GHz), the ACT-Chile survey, to build a catalog of Submillimeter Galaxies distributed over a large area and measure their clustering signal and estimate their spatial correlation length; (3) ACT observations are producing a unique sample of galaxy clusters. Members are carrying out an imaging and spectroscopic survey in order to determine the fraction of real clusters, their redshift and masses.
SMGs. Members have started a project to investigate the link between Submillimiter Galaxies (SMGs) and present-day massive elliptical galaxies, which are believed to be their descendants, through an analysis of their dark matter halo and stellar masses. They are conducting a 870 μm survey of massive galaxy clusters in order to detect lensed background SMGs. This study will help us understand and characterize a population that appears as point sources in ACT maps, which in turn will allow us to refine the selection of SMGs for the construction of our clustering catalogue. During 2009 they mapped one massive cluster with LABOCA and detected a total of 10 sources at 3σ level with fluxes ranging from ~5.3 to ~18 mJy. They have identified possible counterparts from mid-IR

Spitzer. Regarding the analysis of SMGs stellar masses, they are currently working with high-resolution mid-infrared NICMOS imaging for a set of 7 SMGs with known redshitfs. These data will allow us to get some insight into typical rest-frame optical morphologies of SMGs and asses their merger states, and to model the stellar population of their components and determine whether they can account for the large starburst behind SMG luminosities.

Red-Sequence Cluster Survey. Center members and the RCS team continue with the campaign of confirming the reality of the largest sample of strong lensing cluster. The spectroscopic confirmation for a total sample of 70 strong lensing systems is under way. Observing time for a sample of ~30 systems has been obtained at the VLT and Magellan telescopes.

MUSYC. Results from the NIR imaging of the MUSYC fields obtained with the ISPI imager on the Blanco 4m telescope has yielded important results. Members used the photometry in the B,z and K-bands to determine the properties (masses, star formation rates, clustering) of the star-bursting and passive galaxies at z~2. They also studied the rising and the evolution of the Red Sequence of K-selected galaxies. The presence of AGN in X-ray selected galaxies shows that Active Galaxies preferentially populate the "green valley" of the magnitude-colour plot of galaxies, while the presence of Compton Thick sources was studied using a combination of optical, NIR and 24um Spitzer observations.

Lyα Emitters. This project is aimed towards measuring the clustering properties of Lyman Alpha Emitter (LAE) and Lyman Break Galaxies (LBG) in quasar fields. Members will measure the two-point cross-correlation function between LAEs and LBGs, taking advantage of an extensive spectroscopic follow-up of the LBGs and quasars detected in the broadband imaging available in our chosen fields. This dataset provides a large database of LBG redshifts to allow for this cross-correlation calculation. They have successfully detected over 350 LAEs in a pilot imaging program started in during 2009, and have preliminary clustering results for their initial sample. They have proposed for spectroscopic follow-up observations of this sample, as well as new imaging for the rest of the fields, in order to gather a sample of LAEs big enough to beat cosmic variance in their clustering analysis.

QbC. The Quasars behind Clusters (QbC) project makes further progress. Gemini GMOS and VLT UVES data have been reduced and are being analyzed. Several absorbers have been confirmed as cluster members, lending support to our 2008 results. Members have received a first release of RCS2 and a new catalogue of SDSS clusters, both of which they are analyzing.

2. Theory and simulations

Members have reported their simulations of the future evolution of supercluster-like structures. The main effort in this topic during 2009 has been directed towards probing the gravitational collapse of the Shapley Supercluster (SSC) by accurately measuring the distances of individual clusters within it through the Fundamental Plane and comparing them to their respective redshifts. They have advanced on the analysis of the images and spectra of galaxies in two clusters of the SSC taken with the IMACS instrument on the Baade telescope (Magellan I). On the theoretical front, they are in the process of analyzing *virtual observations* of superclusters chosen from a large N-body simulation of cosmological structure formation, in order to determine how clearly each of them would reveal the inverted Hubble flow signature expected from the gravitational collapse.

Using their model for galaxy formation, Center members have started a detailed study of how the accretion of the supermassive black holes in the centers of galaxies proceeds. Comparing with observations, they conclude that the observed level of alignment indicates that some of the angular momentum of the source of the accreted gas is conserved (for example from the hot gas halo) as it falls towards the galactic nucleus. Presently they are working on a new version of the semi-analytic code, which will use the actual orbits of satellite galaxies to take into account galaxy interactions with the hot gas and with other galaxies, with the aim to reach a simpler scheme for the onset of starbursts in mergers and disc instabilities. On the structure formation side, they have recently constructed a new tool to identify filaments in numerical simulations (of dark-matter, using dark-matter haloes) and are studying the reason behind the assembly bias effect.

Area 2: Stellar Populations in the Local Universe (P.I. D. Geisler)

The science undertaken during 2009 in Area 2 can be divided into 3 broad scientific topics: globular clusters systems, studies of nearby galaxies and detailed studies of stellar populations in the Milky Way.

Globular clusters systems. The Center continues its long-term program to study the dynamics of early-type galaxies using globular clusters as tracers. The objectives are to constrain the dark matter halos, to study the relationship between globular cluster subpopulations and their kinematical properties, and to compare the predictions of standard dynamical theories as well as MOND with the observed kinematics. In NGC 1399, the central cD galaxy in the Fornax cluster, Center members have obtained the largest set of globular cluster velocities of any elliptical galaxy, almost 700. The red and blue subpopulations are found to be kinematically distinct. The red clusters resemble the stellar field population while the blue clusters are more likely to have been accreted earlier, during the assembly of the Fornax cluster. In NGC 4636 in Virgo, almost 500 velocities show the dynamics as consistent with being MONDian, but the stellar M/L ratio is still a significant source of uncertainty. Another Virgo elliptical, M84, can be understood as being MONDian with a plausible stellar M/L ratio.

Nearby galaxies. Several studies of nearby galaxies were published during 2009. Center members obtained spectrophotometric data for 28 HII regions in the Sculptor Group spiral galaxy NGC 300 and determined a radial gas-phase oxygen abundance gradient based solely on auroral lines, yielding a value of -0.077 ±0.006 dex/kpc, which agrees very well with the value of -0.081 ± 0.011 dex/kpc obtained by the same group from 29 A and B supergiants. This result places stringent constraints on strong-line abundance indicators commonly used to estimate the chemical compositions of star-forming galaxies. Their study provides the first direct comparison of stellar and nebular abundances in a galaxy beyond the Local Group. Members also obtained near-IR spectra covering the CaII triplet lines for a large number of stars associated with 16 SMC clusters. These data compose the largest available sample of SMC clusters with spectroscopically derived abundances and velocities. They determine mean cluster velocities to typically 2.7 km s-1 and metallicities to 0.05 dex and investigate the metallicity distribution, metallicity gradient, age-metallicity relation and kinematics of the SMC cluster system.

Stellar populations in the Milky Way. Work on our own Galaxy has proceeded on several important fronts. One of these is the fascinating new field of multiple populations in globular clusters, which are traditionally regarded as simple stellar populations with a unique age and abundance. Center members continue to be very active in this field. Stars studied in M22 turned out to possess two populations with different amounts of light-, iron-peak and s- elements. A study of hot HB stars in NGC6752 indicates that HB morphology can be driven by a spread of He and light-element content. This fact, coupled with the MS populations found in other clusters, reinforces the evidence that globular clusters are not as simple systems as previously thought but that they had a period of chemical evolution and distinct episodes of star formation at the beginning of their life. A large-scale spectroscopic study of turnoff stars in Omega Centauri was conducted with the goal of measuring for the first time the Li content in an extragalactic object. The result is that for both the metal poor and intermediate metallicity populations the Li abundance is at the plateau, i.e. the Li content in Omega Cen is the same as in our Galaxy.

Area 3: The Extragalactic Distance Scale. (P.I. W. Gieren)

The principal science activity in this area has been the **Araucaria Project**, a Key Project of the Center. Progress made in 2009 is described below. An additional new program is the determination of distances to Supernova-containing galaxies with one or several of the stellar distance indicators being calibrated in the Araucaria Project, in an effort to improve the calibration of SN Ia and SN II as standard candles, and to foster collaboration with the Supernova area of the Center.

The specific goals of the Araucaria Project are the very substantial reduction of the principal systematic errors on the Hubble constant from the HST KP: the uncertain distance to the LMC,

assumed to be 18.50 mag by the KP; the metallicity sensitivity of the Cepheid Period-Luminosity (PL) Relation; and uncertain correction for Cepheid reddening in the host galaxies of the KP. Besides of improving Cepheids as distance indicators, the Araucaria Project is re-calibrating and applying other stellar techniques of distance measurement, and has provided a new accurate method using spectroscopy of blue supergiant stars (the Flux-Weighted Gravity-Luminosity Relation, FGLR). Once the stellar methods are fully calibrated for their environmental dependences, the Project will derive improved (<5% error) distances to some 30 nearby galaxies, including massive spirals, and calibrate secondary methods (Tully-Fisher, SN, SBF) which will be applied to galaxies beyond the Local Hubble Flow to derive a more accurate value of the Hubble constant (goal: total uncertainty <3%).

Progress in the past 12 months includes the following:
Cepheids surveys/distances: Cepheid surveys were conducted from ESO 2.2m/WFI and LCO Polish 1.3m telescope images for the Sculptor galaxies NGC 247 and NGC 7793. Near-infrared follow-up images previously obtained with VLT/ISAAC in an ESO Large Programme were used to derive reddening-independent distances to both galaxies using our multi-wavelength VIJK technique. NIR images were obtained with VLT/HAWKI for a field in the northern Local Group spiral M 33 which contains about 40 known Cepheid variables. Data reduction is under progress. These IR data will greatly improve the accuracy of the Cepheid distance to M 33 which is one of the most important galaxies in the Araucaria Project, given that most stellar techniques of distance measurement can be applied on it.
Infrared surface brightness (ISB) technique on Cepheids: Members have finished the observations and reductions of the radial velocity curves of 22 LMC Cepheids with periods from 4-45 days and have determined their distances with the ISB technique. This led to a re-calibration of the method through the requirement that the individual distances cannot depend on period. The main results from this study are that the slopes of PL relations, in optical and NIR bands, are the same in Milky Way and LMC and thus independent of metallicity; there is a slight metallicty effect on the PL relation zero point; and the LMC distance modulus is (18.36 ± 0.10) mag. Center members have combined theoretical Cepheid atmospheric codes with accurate radial velocities for 8 Galactic Cepheids to constrain the p-factor relation needed in the ISB analysis. They found a slight inconsistency with the empirical results which is currently not well understood.
Blue supergiant FGLR: Members have applied the calibration of the FGLR obtained by them to the WLM Local Group galaxy using 10 blue supergiants (spectra obtained with VLT/FORS) and obtained a distance accurate to ±5% and in good agreement with the Cepheid infrared distance derived by our group previously. Spectra of blue supergiants in the galaxies NGC 55 and NGC 247 have been analyzed and will lead to FGLR distances soon. They have recently obtained 3 nights with Keck/LRIS-ADC to get spectra of blue supergiants in the massive northern spiral M 81, with the main goal to obtain a reddening-independent accurate distance to M81 which is a main calibrator of far-reaching secondary methods.
Supernova-containing nearby galaxies: The NIR Cepheid distance to the Sculptor Group galaxy NGC 7793 which contains the type-II SN 2008bk has been determined and will be compared to the distance resulting from the analysis of the supernova with the Expanding Photosphere Method recently finished by scientists of the supernova group of the Center.

Area 4: Star Formation. (P.I. G. Garay)

The Center's Star Formation Group, in collaboration with MPG and ESO, continues with a systematic survey of the Galactic Plane at 870 µm with LABOCA: The APEX Telescope Large Area Survey of the Galaxy (ATLASGAL). Dust continuum emission in the sub-millimeter range is the best tracer of the earliest phases of (high-mass) star formation since it is directly probing the material from which the stars form. Successful observing runs were conducted during 2009 to complement the time allocated by ESO and MPG, allowing the completion of the survey. ATLASGAL is the first Galaxy-wide sub-millimeter continuum survey. Combining ATLASGAL with existing and planned Galactic surveys such as GLIMPSE, MIPSGAL, VLA-NVSS, Herschel and NANTEN2, will allow us to answer several open questions about the origin of massive stars. The large number of high-mass proto-stars and proto-clusters identified with ATLASGAL provides an excellent sample for high-angular

resolution observations using ALMA. As a follow-up of ATLASGAL, a proposal to extend the continuum survey to the southern regions of the Galactic plane, to entirely cover the most nearby Galactic arm: the Carina-Sagittarius arm, was submitted and approved. Among the inner spiral arms, only the Carina arm is just partly (~80%) covered in Galactic longitude by ATLASGAL. The remaining 20% contains the cleanest directions, not confused by other arms. Important regions such as NGC7538, RCW79, and Carina Nebula are part of this portion of the Galactic plane.

During 2009, Center members started the study of Infrared Dark Clouds (IRDCs); these are cold, dense molecular clouds seen as extinction features against the bright Galactic infrared background. Many IRDCs are filamentary and contain one or many cores, some of which are undergoing the earliest stages of high-mass star formation. In order to better characterize the various stages of high-mass star formation, as well as the timescales and physical conditions during the collapse into proto-stellar cores, spectra were obtained with APEX toward a sample of high-mass star forming cores within a very filamentary IRDC. Combined with the optically thin sub-millimeter continuum emission from ATLASGAL and GLIMPSE/MIPSGAL images, these spectra provide information to determine many properties such as masses, chemistry and evolutionary states of the cores.

Center members continued the study of 18 young massive star-forming regions at several wavelengths. During 2009 they reported the results of mid-infrared (MIR) observations, made with the TIMMI2 camera on the ESO 3.6 m telescope with an angular resolution of ~1''. Typically, the regions exhibit a single or two compact sources (with sizes in the range 0.008-0.18 pc) plus extended diffuse emission. For the MIR sources associated with radio continuum radiation (reported previously) there is a close morphological correspondence between the two emissions, suggesting that the ionized gas (radio source) and hot dust (MIR source) coexist inside the H II region. Also they found five luminous MIR compact sources which are not associated with radio continuum emission, and are thus prime candidates for hosting young massive protostars.

Center members have developed a Modified Montecarlo Radiative Transfer code. The code uses molecular and cloud parameters to compute the emerging molecular spectrum as a function of impact parameter. These are then convolved to compare directly with the observed mm- and sub-mm wavelength line profiles. They wrote many aspects of the code including: (a) redefining completely the way molecular parameters are specified, using now the Leiden molecular spectroscopy data; (b) separated the cloud definition, the Montecarlo properly to compute equilibrium level abundances, and the ray tracing to produce observed spectra; (c) python routines to fit spectra; a Cartesian 3-d version to be able to derive observed parameters from hydrodynamic simulation model clouds. They are using the code to fit NH3 spectra towards starless cores observed with the VLA and Vilspa.

Area 5: Extrasolar Planets and Brown Dwarfs. (P.I. D. Minniti)

During 2009, members of Area 5 reported the discovery of low-mass companions orbiting five solar-type stars that have emerged from the Magellan Planet Search Program, a precision Doppler velocity survey, with minimum (Msin i) masses ranging from 1.2 to 25 M_{JUP}. The nearby target stars range from mildly metal-poor to metal-rich, and appear to have low chromospheric activity. The companions of the brightest two of these stars have previously been reported from the CORALIE survey. Four of the companions (HD 48265-b, HD 143361-b, HD 28185-b, and HD 111232-b) are low-mass Jupiter-like planets in eccentric intermediate- and long-period orbits. On the other hand, the companion of HD 43848 appears to be a long-period brown dwarf in a very eccentric orbit.

Currently the only technique that is sensitive to Earth mass planets around nearby stars (that are too close for microlensing) is the monitoring of the transit time variations of the transiting extrasolar planets. Center members searched for additional planets in the system of the hot Neptune GJ 436b, and the hot-Jupiter XO-1b, using high cadence observations in the J and Ks bands. New high-precision transit timing measurements were used to derive new ephemeris as well as depths for these transits. Although no statistically significant timing deviations were detected, they

demonstrated that the high cadence ground based near-infrared observations are successful in constraining the mean transit time to ~30 sec., and are a viable alternative to space missions.

Center members reported the detection of the cool, Jovian-mass planet MOA-2007-BLG-400Lb. The planet was detected trough a high-magnification microlensing event (with peak magnification A max = 628) in which the primary lens transited the source, resulting in a dramatic smoothing of the peak of the event. The angular extent of the region perturbed by the planet is significantly smaller than the angular size of the source, and as a result the planetary signature is also smoothed out by the finite source size. Thus the deviation from a single-lens fit is broad and relatively weak (approximately few percent). Nevertheless they demonstrate that the planetary nature of the deviation can be unambiguously ascertained from the gross features of the residuals, and detailed analysis yields a fairly precise planet/star mass ratio, in accord with the large significance of the detection.

During 2009 Center members started the Calan-Hertfordshire Extrasolar Planet Search Program. Under this project they reported the discovery of a brown dwarf on an eccentric orbit and with a semimajor axis that places it in the brown dwarf desert region around the star HD 191760, adding to the small number of metal-rich stars with brown dwarf companions. In addition, they also refined the orbits found for the exoplanets around the stars HD 48265, HD 143361 and HD 154672. Center members also participated actively in the installation of the HAT-South station in the Las Campanas Observatory. HAT-South is a global network of small, custom made telescopes that were installed during 2009 in Australia (Siding Springs), Namibia (HESS site) and Chile (Las Campanas), and that will provide 24-hr monitoring of selected fields to discover transiting exoplanets more efficiently than ever before. After a period of running in debugging mode, the station officially started operations in Nov 2009. Euler/CORALIE and duPont/Echelle runs to confirm transiting exoplanet candidates from HATnet have been undertaken.

Area 6: Supernova and dark energy (P.I. M. Hamuy)

The supernova Area 6 has two main goals. The activities performed during 2009 along these two lines are summarized below.

1. Determination of extragalactic distances using supernovae.

The first step along this research line consists in discovering supernovae. With this purpose Center members are carrying out a systematic search of several hundred galaxies using four of the six PROMPT robotic telescopes at Cerro Tololo. This project, which involves the participation of several undergraduate students, has secured more than 1120 hours of observation during 2009. Every night, several hundred galaxies are observed, the images are downloaded to our computers in Santiago, and an automatic search pipeline is triggered. During 2009 the search project, dubbed CHASE, discovered 36 nearby supernovae, which is close to the goal of 40 discoveries per year. The supernovae discovered by CHASE are all nearby and generally young supernovae ($cz < 25000$ km s^{-1}). At this moment, CHASE is the leader project in the discovery in the southern hemisphere and the second worldwide.

Since the PROMPT telescopes do not belong to the Center's Supernova Team, they have little control on the instrument. This problem led members to consider the possibility to develop their own robotic telescope. During 2009 several parts (mount, optical tube, CCD camera) were purchased from manufacturers in Italy, Russia, US, and Japan, which we expect to integrate during 2010. In parallel they have been working with mechanical engineers from the University of Chile in the design and fabrication of a dome for our telescope, which will be deployed in a building located on Cerro Tololo. During 2010 they will proceed to integrate the telescope and the mount, and to develop the automatic control of the instrument. At this moment they are holding conversations with Spaniard astronomers with vast experience in robotic telescopes.

The second step in this research line is obtaining photometric and spectrometric follow-up data for the discovered supernovae by CHASE (and additional equatorial or southern supernovae found at other observatories). This project is done in collaboration with the Carnegie Supernova Program, that uses 280 nights every year in the 1 and 2.5m telescopes in the Las Campanas Observatory, in the north of Chile, to study supernovae with redshifts less than 0.07. During 2009 the collaboration with CSP observed a total of 33 supernovae, in the ugriYJHK filters and with optical spectrographs. Works in developing several distance determination methods using the first sample of the CSP type Ia supernovae obtained between 2004-2006 were recently made.

2. The physics of supernovae

During 2009, Center members have developed a hydrodynamic code to model type II plateau supernovae. The code takes as initial model a double polytrope that describes a compact core with an extended envelope. It injects energy to the central zone and correctly models the light curve of the prototype of this class of objects (SN 1999em) with reasonable physical parameters for the progenitor star (mass and initial radius). They will soon start a more systematic exploration of the parameter space. Moreover, they have computed, and reported, bolometric corrections for type II plateau supernovae based on three objects with optical and infrared photometry and two sets of atmospheric models. These corrections permit the calculation of bolometric light curves using BVI photometry. They have applied the method to 30+ objects that have optical observations, which will allow modeling with their hydrodynamic code.

Within this research line they have also focused on the study of exotic types of supernovae: Ib, Ic and IIb. Given that these objects result from the gravitational collapse of the cores of stars that have lost their external envelope in different degrees, they provide an optimal scenario for the study of the physical processes that happen in their deep interior. During 2009, Center members started exploring the CSP supernova database for these types of objects.

Area 7. Astronomical instrumentation (P.I. L. Bronfman)

The main goal of this area is to design and construct a prototype receiver cartridge for the ALMA Band 1, covering the frequency range between 31.3 GHz to 45 GHz. The Millimeter-wave Laboratory at the National Astronomical Observatory in Cerro Calán, where the receiver prototype will be built, has undergone a rapid development. The main activities performed during 2009 are summarized below.

A preliminary physical layout of the receiver was produced and the key components specified. The construction of key optic components was carried out in the laboratory machine-shop, including the receiver feed horn and the ortho modal transducer (OMT), and a set-up was implemented for measuring the horn beam pattern. For developing the RF amplifier, one of the key components, an amplification system was designed, built, and tested at the laboratory; this included the design and construction, at the laboratory machine-shop, of a package to mount a commercial HEMT amplifier. Design of low noise HEMT amplifiers took place in collaboration with U. Manchester. Cryogenic capabilities were acquired by the end of the year and are presently being installed.

A prototype Ortho Modal Transducer (OMT), to separate the polarizations, was designed, and constructed in aluminum using the CNC machine; its performance was measured in the lab and is very close to the simulated HFSS results. A spline line corrugated feed horn, whose design improves over the traditional corrugated horn, was also constructed with the CNC machine and will be tested soon. Further design work is underway to optimize its performance. A circular to square transition for connecting horn with OMT was also built at the machine-shop. Different optical configurations were studied for the lens, taking into account the dimension and constraints of the ALMA antennas, as well as different materials for constructing the lens.

An automated near radiation field beam pattern measurement system was designed and completed. This system is fundamental to verify the performance of the optic components, by testing the reflections, transmissions, and the radiation amplitude/phase pattern performances of our constructed horns and lenses. The control system and its data acquisition processing software were all developed completely in our lab. The setup was tested by successfully measuring the performance of a commercial pyramidal horn. Different microwave waveguide transitions and loads (e.g. with circular, square, and rectangular inputs/outputs geometry) were built, to be used in the inter-connection of different microwave devices when calibrating the measuring systems.

A first amplifier for band 1 was designed, fabricated and tested. The initial efforts were focused on developing packaging capabilities so a commercial chip containing a low-noise amplifier (model ALH376 from HITITTE) based on HEMT transistors has been used. The design started with developing a transition from a WR22 rectangular waveguide to a 50 Ω micro-strip line, which corresponds to the input port of the commercial chip. This transition uses a circular strip-line antenna. A polarization printed circuit board (PCB) was also produced in-house, to energize the amplifier, and a split-block to pack all components. The packaging block and the strip-line antennas were built using the CNC milling machine at the lab workshop. Finally, the response of the packaged amplifier was analyzed using the laboratory Vector Network Analyzer (VNA). The results showed a 15dB gain in the whole bandwidth, which is consistent with the specifications of the commercial amplifier.

By the end of 2009 the laboratory received, in an extended loan basis, two receivers equipped with 10K cold heads, with two helium compressors, in a long term lease from CalTech CBI telescope. While these receivers will be used as test cryostats in the lab, they are also very didactical for the students because the frequency of operation is quite similar as that of the ALMA band 1. In March 2010 the laboratory received a complete ALMA compatible test cryostat, built by the National Astronomy Observatory of Japan (NAOJ), together with a Sumitomo Compressor and Cold Head, which will allow the testing of a full receiver system in a setting 100% equivalent to the ALMA cryostat.

In the area of Robotics, members have bought and received all the main components of the robotic telescope, designed and built a dome to be installed in the final site, coordinated the main tasks and people that are necessary in this type of project, as well as developed new tools for the supernova search program that will be possible to implement when the robotic observatory is running. The dome has been designed and built in Chile. It will be installed in Cerro Tololo in mid May 2010 and will be tested without the telescope during the winter. For the dome we have spent similar resources between the steel structure, the fiberglass coating, the hydraulic and electronic system and the. costs of design, supervision, transport and installation. The design and construction supervision have been done by Marco Ruiz, a young mechanical engineer from Universidad de Chile. We are in the process of buying the computers to be used on site, as well as the many peripherals required for the correct working of the observatory, e.g. webcams, weather station and backup systems. We have also installed and tested the mount that will hold the other components of the telescope at Cerro Calan.

Area 8. High Performance Astronomical Computing (P.I. A. Clocchiatti)

With the purchases made during 2009, the supercomputer of the High Performance Computing Center currently consists of 128 CPUs (512 cores), 512 GB of RAM, 39 TB of disk space, 3 KVA UPS, 10 Gigabit Ethernet and a 19" rack. It is the most powerful machine in Latin-America devoted to astrophysical research. Early during 2009, the computer went through a period of software installation and testing, including mid-sized cosmological numerical simulations. Full fledged operation started in mid 2009. Initial science runs include simulations of star forming in primordial composition gas (theory of "population III" stars), the largest cosmological simulation in Chile so far, and phenomenological parameter constraints on the shapes of AGN hosts in the SDSS. All these projects involve the participation of graduate students. In addition, we started giving support to

researchers at Universidad de Valparaíso, opening direct gates for them to submit jobs and to retrieve results.

Several problems in astrophysics are highly nonlinear and cover a huge dynamical range, therefore they must be solved numerically. In particular, the research interests of CATA members performing theoretical astrophysics are focused on problems of formation of structures in the universe, which requires enormous computing power. So far members have performed SPH/AMR simulations using typically a million particles/cells which run for weeks in machines with 16 to 32 cores. With the new resources at the High Performance Computing Center of CATA, they are now able to run onto 128 cores, hence drastically decreasing the processing time and allowing an increase in the numerical resolution of their codes and permitting to include large scale (boundary) effects. With this facility at hand, Center members will be able to address challenging problems such as: What is the fate of massive black holes (MBH) after a galaxy merger? How fast a MBH can be feed and grow in a gas rich environment? What determine the characteristic scale of massive (globular-type) star clusters? How do massive and dense cores evolve to produce a cluster of high-mass stars?

2.- Training of human resources of excellence.

CATA is supporting the formation of human resources in astrophysics in all of the Astronomy programs in the country. The number of graduate astronomy students at the three institutions associated to the Center continues to increase with respect to the average value of the last decade. During 2009 there were forty (40) Ph.D. students in astronomy (21 at the Pontificia Universidad Católica, 13 at the Universidad de Chile, and 6 at the Universidad de Concepción) and twenty six (26) students in Master's in Astrophysics programs (11 at Pontificia Universidad Católica and 15 at the Universidad de Chile). Most of these students have taken advantage of the Center being granted funds in order to participate in observing runs at the International Observatories in Chile and/or to attend international meetings. In addition, the Center has given full/partial fellowships to a dozen of graduate students, allocating a total of $15.000.000 in this item during its second year of operation. During 2009, more than thirty graduate and undergraduate students were working in individual science projects associated with Key Projects.

During 2009, four astronomy students obtained their Ph.D. degree, 3 at Pontificia Universidad Católica (Miguel Fernandez, Roberto Muñoz and Rolando Dunner) and 1 at Universidad de Chile (Matias Radiszcz) and eight students obtained their Master degree, 5 at Pontificia Universidad Católica (Claudia Lagos, María Escobar, Basilio Solis, Rodrigo Herrera and Paulina Troncoso) and 3 at Universidad de Chile (Cynthia Herrera, Nicolas Tejos and Matias Vidal).

CATA is also allowing a substantial increase in the human resources devoted to the development of astronomical instrumentation in Chile. Currently, four students are involved in the development of the Band 1 receiver prototype project. Nicolas Reyes (EE Ph.D. student) is involved in the design and construction of the radio-frequency components of the receiver, including the low-noise first stage amplifier (31 - 45 GHz). Pablo Zorzi (EE Ph.D. student), is involved in the design and construction of the receiver optics. Franco Colleoni (EE Master student) designed and completed an automated near radiation field beam pattern measurement system. Claudio Jarufe (EE Master student) designed, fabricated and tested a first amplifier for band 1 (Memoir).

During September 2010, Pablo Zorzi visited the Hertzberg Institute of Astrophysics, HIA in Victoria, Canada, carrying on a detailed study of 4 different optical layout configurations and their noise performance responses between 30 and 50 GHz. Efforts concentrated on the optimization of the lens shapes, antireflection surface matching techniques, and the use of different materials to improve the overall noise performances of the optics.

Between October, 2009 and March 2010, Reyes visited the University of Manchester to carry out research on HEMT amplifiers. The main topics were: (a) Noise and small signal modeling of high

frequency transistors. This consisted of the measurement and modeling of InP p-HEMT transistors grown at the University of Manchester facilities. The work was done under the supervision of Prof. Mohamed Missous; (b) Design of Low Noise Amplifiers using microwave CAD tools. A hybrid amplifier based on UMS (United Monolithic Semiconductor) transistors was designed, using ADS (Advanced Design System) following the successful experience of the Planck 30 GHz amplifier. The work was done in close collaboration with the Planck team and with Prof. Danielle Kettle; and (c) Cryogenic low noise measurements. Reyes also visited the Centro Astronómico de Yebes, Spain, where he learned about low noise cryogenic measurement techniques.

During the second year of operation CATA allowed the hiring of 2 new Postdoctoral fellows, allocating $25.000.000 in this item. The postdoctoral fellows are expected to be key elements in establishing strong scientific collaborations between all associated astronomical Institutions.

3.- 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).

Regarding the astronomical instrumentation area, there are two main ways in which the development of Band 1 receiver technology for ALMA will impact the competitiveness of Chilean economy. The first area is high frequency communications. Through the development of local know-how in the frequency range covered by the Band 1 of ALMA, 31.3 GHz to 45 GHz, Chilean engineers are gaining extremely valuable experience in the field of communications technology, particularly in the field of High Electron Mobility Transistors (HEMT), which will be used in future high frequency satellite communications. Second, students of the new PhD programs in Electrical Engineering specializing in astronomical instrumentation and carrying on research in receiver technology will form the core of a new high technology nascent industry oriented to satisfy the future receiver maintenance and upgrade needs of the observatories in Chile, both ALMA and others being planned.

There are several other lines of work on instruments and telescopes, at each of the branches of the Center, which are also expected to increase the competitiveness of Chilean engineers and have in the near future an impact on the industry. Among them we mention:

BESOS: A Low Resolution - High Efficiency Compact Spectrograph. This is a test probe project which was used to train people in the construction of mechanical and optical parts. With exception made of the optics, it was built at PUC workshops. It has a range of 362-812 nm, a resolution ~200, and a peak transmission ~80%.

IR Laboratory: An infrared laboratory was established at the School of Engineering of PUC with the support of the Astronomy and Astrophysics Department. Funding was provided by CATA, the ESO-Chile fund for development of Astronomy and a donation of hardware from Arcetri University. The lab carries a cooled grating near infrared spectrometer which provides low and medium resolution spectroscopy in the 0.9 – 2.5 um spectral range. It is a cryogenic instrument cooled by liquid nitrogen at 70 K and employs as detector the Rockwell NICMOS HgCdTe 256x256 array. The instrument has been tested and is undergoing improvements in electronics and light path.

SIMPLE: Funding was obtained to participate in a consortium of three institutes from ESO member states, namely the Instituto Nazionale di Astrofisica (INAF) from Italy, the Uppsala Astronomical Observatory and Universitet (UAO) from Sweden, the Thüringer Landessternwarte Tautenburg (TLS) from Germany, and one institute from ESO host state, namely the Pontificia Universidad Catolica, Chile, that studies the feasibility of SIMPLE. This will be a high resolution infrared spectrograph for the ESO-ELT. The SIMPLE group from PUC involves professors and students of astronomy and engineer.

Engineers, technicians and astronomers at PUC participated in the installation of an f/5 system at the Magellan telescopes in order to use Megacam and MMIRS on them. Vincent Suc, engineer at PUC, has been instrumental in this process and will perform support in 2010 for Megacam and MMIRS

when they are up in the telescope. His participation in the teams of these sophisticated instruments has provided much expertise that he will share on our ongoing instrumentation efforts.

4.- Activities of support to other national research groups.

As one of the main thrusts of our CATA is to increase human resources and networks for National Astronomy, we have a strong commitment to help groups of excellence at other Universities. We have decided to foster collaborations with selected researchers at the Astronomy Departments of the University of Valparaiso (UV), University of La Serena (ULS) and University Andres Bello (UAB).

This goal is materialized in three different lines of action: support for scientific activities of researchers, support for post-doctoral fellows and support for scientific workshops. These actions will allow us to open new venues of collaboration and networking, sorting out the usual administrative difficulties that involve the interaction of different Universities. The specific activities accomplished in these areas were:

- Support for associated researchers:
  Prof. Veronica Motta (UV) through travel funds to go to Europe.
  Prof. Jura Borissova (UV) through travel funds to go to Europe.
  Dr. Matthias Schreiber (UV) through travel funds to go to USA and Europe.
  Dr. Giuliano Pignata (UAB) through travel funds to go to USA.

- Support for Postdoctoral Researchers:
  Salary of Guillermo Gundthardt (ULS) to work with Prof. Rodolfo Barba.
  Support for travel and expenses of Dr. Saurabh Sharma at UV working with Prof. Jura Borissova.
  Salary of Roberto Muñoz (UV) to work with Prof. Veronica Motta.
  New opening of a joint position between Universidad de Concepcion and Universidad de Valparaiso for a postdoctoral fellow that will arrive this year.

- Support for Scientific Workshops and Networking:
  Funds for Veronica Motta to organize a group Workshop on lensing at UV.
  Support for scientists at UV and ULS to attend the fourth and fifth VVV Science Team Workshops.
  Support for scientists at UV and ULS to attend the ASTROBIO 2010 Workshop.

5-. Outreach and dissemination of the Center's activities and/or synergies with science education.

CATA is actively supporting outreach activities in order to strengthen the mission of attracting young minds to cultivate science as well as to get a better visibility on the general public. In what follows we list the main outreach activities.

WEB sites.
The WEB site www.cata.cl was created during 2009.

A new WEB site in Spanish of astronomical information has been developed. A long glossary of astronomical terms has been created. Basic astronomical data has been posted and a list of questions and answers has been developed keeping in mind high school students as well as grammar students. Biographies of selected astronomers are been created. The web site is www.astro.uchile.cl.

Popular books.
During 2009, Center member José Maza prepared and published a new edition of his introductory astronomy book "Astronomía Contemporánea" written for high school children. The book, originally

published in 1988, has been out of print for at least a decade. The new edition by "Ediciones B" was released in early November 2009. In the first two months the book sold 650 copies, an excellent number for the Chilean book market.

CATA Director, María Teresa Ruiz, prepared and published a popular book in astronomy including poems by Margarita Schultz, entitled "Voces del Universo / Voices from the Universe". It was published by "Ocho Libros Editores Ltda" in a bilingual edition Spanish/English. Presented in a big format it is a beautiful "Coffee Table Book".

Public talks.

During 2009, CATA supported the "Cycle of Talks in Public Schools". Ten schools were visited in several towns of Santiago and another ten in the XII Region (Punta Arenas, Puerto Natales and Porvenir). The talks were attended by more than 2000 students and 100 teachers. Along with the power point presentations, small booklets, 16 pages long each, were prepared containing the material of the lectures. We are now in the process of printing those booklets in order to have them ready for the cycle of lectures we will deliver in 2010 in high schools and grammar schools in poor neighborhoods in the outskirts of Santiago.

Most of the Center members participated in the cycle of talks entitled *Puro Chile es tu Cielo Azulado,* organized by the Explora-Conicyt Program. Talks were given in both large and small cities along the whole country, from Putre in the North to Punta Arenas in the South.

Media coverage.

Information about CATA members and their research was periodically presented in Chilean mass media, such as the TV stations TVN and Canal 13 Cable, the newspapers El Mercurio, La Nación and La Tercera, Revista Ercilla, radios Duna, Agricultura and Universidad de Chile, and web pages, like Emol, Universia, Conicyt.cl, Terra, Uchile.cl, and Explora-Conicyt.

International Year of Astronomy.

See the associated Table for a list of the many activities supported by CATA to celebrate the International Year of Astronomy.

Please highlight unexpected or unanticipated outcomes and indicate what has been done to deal with them.

No unexpected outcomes to report.

IV. USE OF INVESTMENT FUNDS

In no more than three pages report the acquisitions in equipment and construction or improvement of infrastructure made with the Investment Funds. Refer to the use of this equipment and its impact. In case there is any delay in the acquisition, indicate the reason.
The details of this item must be reported in Appendix A14 and A15.

The Atacama Large Millimeter/sub-millimeter Array, ALMA, will be the largest array telescope in the world, consisting of 66 high precision antennas, each housing 10 low-noise receivers in different bands between 31 and 950 GHz. These receivers are being designed and fabricated at different laboratories around the world. A prototype receiver for the lowest frequency band, namely Band 1, covering the 31.3 - 45 GHz range, is being developed by the Astronomy Department, in collaboration with the Electrical Engineering Department at Universidad de Chile, with the support of the Center of Excellence in Astrophysics and Associated Technologies (PBF 06).

Two major pieces of equipment have been purchased to set up the Millimeter-wave Laboratory at the National Astronomical Observatory in Cerro Calán; a high sensitivity Vector Network Analyzer, an instrument that allows to completely characterize the behavior of electronic components in the range 50 MHz to 50 GHz, and a high-precision (1 micrometer positioning) Computer Numerically Controlled (CNC) Drilling and Milling Machine (KERN Micro-und Feinwerktechnik MMP2522), which allows construction of the fundamental components of the ALMA Band 1 receiver prototype cartridge. The Millimeter-wave Laboratory and complementary machine shop have been totally reconditioned to install the newly acquired equipment. International collaboration was established with the Herzberg Institute for Astrophysics (HIA-Victoria) and with the Academia SInica (ASIAA-Taipei), Taiwan.

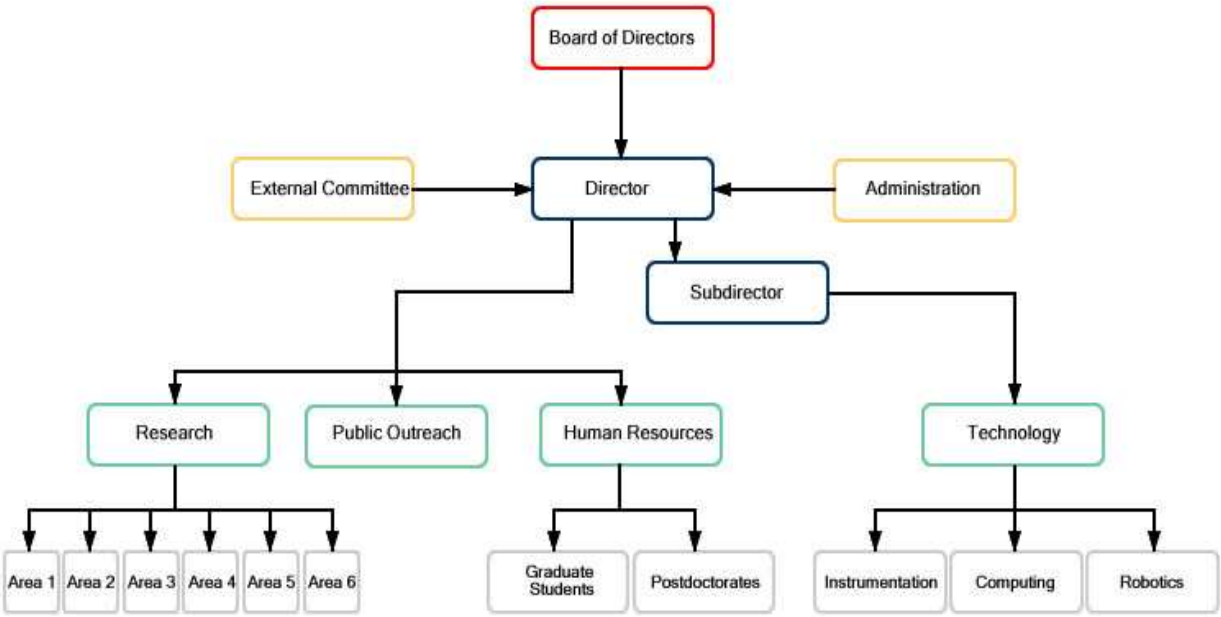
Concerning major equipment, during 2009 we procured from the National Astronomical Observatory of Japan (NAOJ) an “ALMA Cartridge Test Cryostat”, with a matching Sumitomo compressor (SHI CNA61D) and cold head (SHI RDK-3ST-R2), for a total value of US$ 141.600. In addition, in order to be able to make new pieces to the highest precision obtainable with the Kern CNC milling machine, we purchased holders, high precision collets for the CNC machine, assorted high precision cutting tools and an ultrasonic bath for deep cleaning. Furthermore, to proceed with the development of Band 1 we purchased connectors, microwave adapters, an optical breadboard and accessories for antenna pattern measurements.

To build the Robotic telescope, we purchased from the Italian company A&M an optical tube which has a 50 cm primary mirror, a Ritchey-Chretien optical system and a carbon fiber open-truss structure (USD 54.088). We also bought, from the American company Finger Lakes Instrumentation, a CCD camera (USD 52,522) and a filter wheel (USD 18,100). The camera is a 2k x 2k, 95% peak quantum efficiency, blue-enhanced CCD camera, specially chosen to detect young supernova events, as well as allowing precise photometric follow-up observations. The filter wheel has 12 slots. The filters were purchased from the Japanese company Asahi-Spectra, they include the Johnson system filters BV, SDSS system g'r'i'z' and WFCAM Z. We have also designed and built an automated dome (USD 33,580).

V. PROJECT MANAGEMENT

Please use this section to summarize the management activities of the Center during the period. Amongst others, this section should include the alignment of the organization and management model with the objectives of the Development Plan. In the case of changes made after the approval of the development plan, please modify the organizational flowchart.

Organizational Flowchart of the Center



Director : María Teresa Ruiz G.

Sub-Director : Guido Garay B.

External Committee: Mark Phillips (Chair), Lars Nyman, Rainer Mauersberger, Tom Wilson

Administration: Administrators: Erika Rojas and Patricia Monroy
Secretary: Mariela Fajardo

Research : L. Infante. P.I. Area 1
D. Geisler P.I. Area 2
W. Gieren P.I. Area 3
G. Garay P.I. Area 4
D. Minniti P.I. Area 5
M. Hamuy P.I. Area 6

Human Resources : D. Minniti . – G. Garay – W. Gieren

Technology : L. Bronfman P.I. Instrumentation
A. Clocchiatti P.I. Computing
M. Hamuy P.I. Robotics

Public Outreach : José Maza

VI. LESSONS LEARNED

The following section should provide information on substantive lessons about the research, teaching, outreach and other activities undertaken. An explanation should be provided on why things are going right, why things are not working out as anticipated and what the project is doing about it.

Include a summary of the recommendations from the previous reviews (if any) and indicate how they have been considered in the present period.

Do not extend further than 2 pages. Indicate the need of confidentiality if required.

VII. PERFORMANCE INDICATORS

The following section is a summary of the information provided in the previous sections.
Please complete the base line and the data for the reported period. When it does not correspond, indicate not applicable with N/A.

DEVELOPMENT AREAS	INDICATORS	BASE LINE(*)	REPORTED PERIOD	
			Basal Financing Funds(+)	Other Sources
GENERAL	Number of Principal Investigators	**10**	**10**	
	Female Gender (%) of Principal Investigators	**10%**	**10%**	
	Number of other Investigators	**15**	**28**	
	Female Gender (%) of other Investigators	**15%**	**15%**	
SCIENTIFIC EXCELLENCE	Number of ISI publications	**70**	**109**	
	Number of non ISI publications	**40**	**96**	
	Number of citations in ISI Journals	**280**	**828**	
	Percentage of publications Co-authored with national/international researchers from other institutions	**80%**	**94%**	
	Percentage of publications Co-authored with researchers of the Center	**20%**	**34%**	
	Average number of citations per article	**4**	**7**	
	Number of international exchange networks			
	Number of national presentations/conferences	**8**	**18**	
	Number of international presentations/conferences	**25**	**40**	
TRAINING OF HUMAN RESOURCES	Number of undergraduate students			
	Number of female (%) undergraduate students			
	Number of completed undergraduate theses			
	Number of Master students	**24**	**18**	**8**
	Number of female (%) Master students	**33%**	**35%**	
	Number of completed master theses	**4**	**8**	
	Number of Ph.D. students	**22**	**28**	**12**
	Number of female (%) Ph.D. students	**33%**	**33%**	
	Number of completed Ph.D. theses	**2**	**4**	
	Number of posdocs working in the Center	**18**	**10**	**15**
	Number of female posdocs(%) working in the Center	**16%**	**20%**	
	Number of stays/visits from students or researchers from other Centers or projects (national and international)	**15**	**6**	**16**
	Number of stays/visits to other institutions by students or researchers of the Center	**20**	**12**	**9**

DEVELOPMENT AREAS	INDICATORS	BASE LINE(*)	REPORTED PERIOD	
			Basal Financing Funds(+)	Other Sources
TECHNOLOGICAL TRANSFER AND LINKAGE WITH OTHER SECTORS OF CHILEAN ECONOMY AND SOCIETY	Number of patent applications	**0**	**0**	
	Number of patents granted	**0**	**0**	
	Number of licenses and/or Technology Transfer Agreements applied and/or granted	**0**	**0**	
	Number of spin-offs companies rising from the Center	**0**	**0**	
	Number of doctorates and postdoctorates inserted in the Industry	**0**	**0**	
	Number of participations in instances of public policy definition (consulting councils, advisory committees).	**0**	**0**	
	Number of participations in other relevant institutions	**0**	**0**	
	Amount and % of the Center´s income from private sector companies (in cash and in kind (non cash) contributions can be considered).	**0**	**0**	
	Amount and % of the Center´s income from other non-government sources (in cash and in kind (non cash) contributions can be considered).	**0**	**0**	
SUPPORT TO OTHER RESEARCH GROUPS	Percentage of ISI publications co-authored with national researchers (from other institutions).	**2%**	**3%**	
	Percentage of theses co-tutored with national researchers from other institutions.	**0**	**0**	
	% of equipment available to researchers who are not part of the Center.	**0%**	**15%**	
OUTREACH ACTIVITIES	Number of outreach and/or extension activities.	**10**	**20**	
	Total number of people attending to outreach and/or extension activities.	**1000**	**100000**	
	Number of times the project appears in mass media.	**0**	**4**	
	Number of documents, reports, proceedings resulting from outreach/extramural events or activities.			
OTHERS				

(*) Base line is the average indicator from the last 3 years before the application (presented in the Application Form).

(+) Including resources from the Basal Financing Program and resources from other significant and stable public sources, such as: FONDAP, Institutes and Groups of the Millennium Scientific Initiative (ICM) and Regional Center Associations in Science and Technology, Team Research Projects in Science and Technology.

COMMENTS ON THE INDICATORS

If applicable, in no more than 2 pages include your comments on the indicators; explain possible gaps between the ones reported v/s the ones estimated in the proposal.

VIII. FINANCIAL STATEMENT

FUNDS OBTAINED

Please indicate the funds obtained in the reported period using the following table:

MAIN FUNDING		Amount (M$)	% of total
Main Public Funding - Significant and Stable			
CONICYT	Team Research Projects in Science & Technology (PBCT) - PIA	640000	29
	FONDAP	600000	27
	Regional Centers		
MSI	Millennium Institutes	295820	14
	Millennium Nuclei		
COUNTERPART FUNDING			
Less Important Public Competition Funds			
CONICYT	FONDECYT	355900	16
	FONDEF		
	INTERNATIONAL COOPERATION		
CORFO	sCORFO - INNOVA		
Other, insert rows	*Name of the institution*		
Private Sources - National or International Non-Profit or For-Profit Organizations			
National Sources			
Corporations	*Name of the institution*		
Non-profit Org.	*Name of the institution*		
Other, insert rows	*Name of the institution*		
International Sources			
Corporations	*Name of the institution*		
Non-profit Org.	ALMA	123200	6
	GEMINI	93500	4
	ESO	49500	2
	European Union	33000	2
Other, insert rows	*Name of the institution*		
Contributions from the Sponsoring Entity			
	Name of the institution		

APPENDIXES

Attached tables (A1 – A16) and requested documents.

1) Scientific and Technological Research

a) Publications	Enclose all the information of the Publications resulting from the informed period in Appendix A1, A2 and A3. Do not include manuscripts in preparation or submitted in this section, only copies of the preprints of articles published. Indicate those international collaborators in the author's list of each paper or manuscript by underlining their names. Include a digital copy of each paper published
b) Awards	Report this item in Appendix A4
c) Organization of Scientific Events	Report the congresses, courses, conferences, workshops or symposia organized by the Center in Appendix A5. Include a digital copy of the abstracts or full manuscript of the presentations and attach a digital copy of the front page of the scientific event.
d) Participation in Scientific Events.	Report the participation in congresses, courses, conferences, workshops or symposia in Appendix A6. Include a digital copy of the abstracts or full manuscript of the presentations and attach a digital copy of the front page of the scientific event.

2) Training of Human Resources of Excellence

a) Theses	Report this item in Appendix A8. If the theses are already finished, please attach a digital copy of the abstract and the subject index.
b) Postdoctoral Fellows	Report all postdoctoral fellows working in the Center, regardless the funding sources, in Appendix A9.

3) Applications of Research Results into Actions that Contribute to Increment the Competitiveness of Chilean Economy

National or International patents applied for or granted	Report this item in Appendix A11.
Participation in public policy events and the private sector	Report this item in Appendix A12.
Generation of licenses and spin-offs, services or other initiatives	Report this item in Appendix A13.

4) Support to Other Research Groups

Indicate the publications with the co-authorship of researchers from other institutions	Report this item in Appendix A1, A2 y A3
Indicate the theses co-directed with researchers from other institutions	Report this item in Appendix A8
Indicate Research Stage	Report this item in Appendix A7
Indicate the participation in R&D Projects directed by other Research Group	Report this item in Appendix A7

5) Outreach Activities

Report theses activities in Appendix A10