Large Latin America Millimeter/submillimeter Array

LLAMA News
June 2021 – nº 3

Newsletter of the Argentina-Brazil binational collaboration for the development of a new radio observatory in Salta, at 4.850 meters of altitude.

In this issue:

Ministerio de Ciencia, Tecnología e Innovación Argentina

FAPESP

www.llamaobservatory.org

Forewords

With this publication we are resuming the series of newsletters about the development of the LLAMA radio observatory, whose previous editions were published in 2016 and 2017. In view of the long interval, we begin this new edition with an overview of the project to introduce it mainly to more recent generations of graduate students and postdocs.

In this number, we describe recent events based on the evaluation of the project by an international panel of experts, constituted on the initiative of the "Ministerio de Ciencia, Tecnología e Innovación" (MinCyT, Argentina). Some developments, such as the incorporation of INVAP into the collaboration, are presented along with the current status of some of the subsystems that are being developed to bring LLAMA to its first light.

This edition ends with an invitation to the LLAMA-IAFE 2021 Seminar cycle, which takes place monthly in online format starting in June this year, with the expectation of a broad participation of the international scientific community.

Good reading!

LLAMA Collaboration Science Group.

LLAMA Collaboration

Main financial support

"Fundação de Amparo à Pesquisa do Estado de São Paulo" (FAPESP, Brasil)
"Ministerio de la Ciencia Tecnología e Innovación" (MinCyT, Argentina)

Participating institutions

Argentina: IAR, IAFE, CNEA, INVAP; Brazil: USP, Mackenzie, INPE

Steering Committee (May 2021)

Argentina: Alberto Etchegoyen (ITeDa); Carlos Valotto (OAC); Manuel Fernández-López (IAR); Sergio Parón (IAFE); Silvina Cichowolski (IAFE);

Brazil: Jacques Lépine (IAG/USP - Director); Zulema Abraham (IAG/USP); Elisabete Dal Pino (IAG/USP); Carola Dobrigkeit (UNICAMP); Guillermo Giménez de Castro (UPM); José Roberto Marcondes Cesar Jr. (FAPESP).

Science group (May 2021)

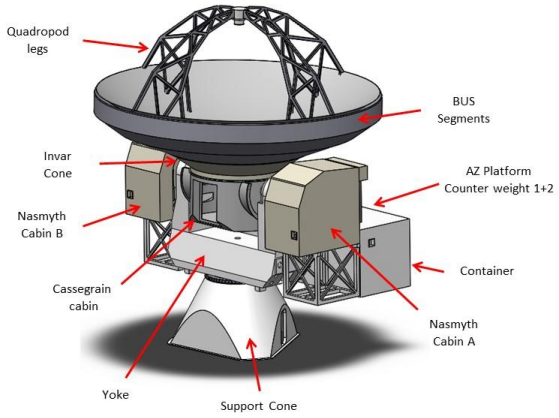
Carlos Valotto (OAC, Argentina); César Strauss (INPE/MCTI, Brazil); Danilo Zanella (IAG/USP, Brasil); Germán Cristiani (IAFE, Argentina); Guillermo Gimenez de Castro (CRAAM/UPM, Brasil); Joaquim E.R. Costa (INPE/MCTI, Brazil); Jacques Lépine (IAG/USP, Brazil); Juan José Larrarte (IAR, Argentina); Laura Suad (IAFE, Argentina); Manuel Fernández-López (IAR, Argentina) - chair; Nicolas Duronea (IALP, Argentina); Silvina Cichowolski (IAFE, Argentina); Tânia Dominici (MAST/MCTI, Brazil); Zulema Abraham (IAG/USP, Brazil).

LLAMA overview

An effective step towards materializing the idea of building and operating a radio telescope through a collaboration between Argentina and Brazil was the initiative of Dr. Félix Mirabel (IAFE/Argentina) to propose, in the 2000s, a search for sites of excellence in northwestern Argentina, where it would be possible to have atmospheric opacity similar to the Chilean sites where the APEX and ALMA observatories are installed. After six years of work, Alto Chorrillos was selected, a site at an altitude of 4850m in Salta.

Mobilization between researchers from Argentina and Brazil to make the observatory possible began in 2007. In 2010, the project already called LLAMA (Large Latin American Millimeter/submillimeter Array) was presented to MinCyT (Argentina), which in the following year declared it a priority among astronomical instrumentation projects in the country. At the same time, researchers from Brazil obtained financing for the acquisition of the antenna with resources from the São Paulo Research Foundation (FAPESP, Process nº: 11/51676-9), in a proposal coordinated by Jacques Lépine (IAG/USP). In 2014, an agreement was signed between MinCyT (Argentina), FAPESP and the University of São Paulo (Brazil).

The radio telescope is based on the same design of the antennas manufactured by the German company VERTEX AntenenTechnik GmbH for the ALMA (Atacama Large Millimeter/submillimeter Array). With 12 meters apperture, the antenna has a Cassegrain focus and two Nasmyth cabins (similar to those of APEX - Atacama Pathfinder Experiment), thus offering the possibility of receiving a wide variety of peripheral instruments. Once assembled, and at the time of acceptance for the start of the commissioning and science verification phase, the surface of the antenna shall have a rms accuracy of 25 μm, with the expected pointing accuracy of at least 2 arcseconds.



Overview of LLAMA's antenna with an indication of some of its main components.

LLAMA will initially be equipped with ALMA-like receivers and, in particular, bands 5 (157 - 212 GHz) and 9 (602 - 720 GHz), installed in a cryostat acquired from the National Astronomical Observatory of Japan (NAOJ). The front-end of the receivers, including the cartridges, were acquired and developed thanks to contributions from the Netherlands Research School for Astronomy, Nederlandse Organisatie voor Wetenschappelijk (NOVA, NWO; Netherlands), Onsala Space Observatory (OSO, Sweden) and National Radio Astronomy Observatory (USA). The opto-electrical-mechanical system to guide the radiation from the primary focus of the antenna to the different cabins and receivers, called NAsmyth Cabin Optical System (NACOS), is an original development of the LLAMA collaboration.

The antenna has already been manufactured and is now disassembled on site, awaiting the completion of infrastructure works and, in particular, civil works for the execution of the antenna base. Considering the extensive and diverse impacts of the pandemic, the current schedule foresees that the assembly of the antenna will take place during 2022 and the commissioning and science verification activities will start from 2023.

Evaluation of LLAMA by an External Committee

In the first semester of 2020, MinCyT asked an external committee to evaluate the development of LLAMA. The committee comprised Matias Zaldarriaga (Princeton, USA – panel coordinator), Gabriela Gonzalez (Louisiana State University – LIGO Collaboration, USA), Hugo Loffler (INVAP, Argentina), Lars Nyman (APEX, Chile), Rodrigo Reeves (Universidad de Concepción, Chile) and Thijs de Graauw (ALMA). After a process that included documentation review and meetings, the panel presented a final report in August 2020.

Among other points, the committee pointed out the immediate need to develop a security plan for accessing the site and safeguarding the equipment. Reorganization of the project structure was recommended, as well as the development of long-term strategies to expand the user community in millimeter/submillimeter wavelengths in both Argentina and Brazil. Some of the efforts made to follow the committee's recommendations are already reported in this publication.

LLAMA site with the antenna components disassembled.

Activities for NACOS optical alignment at ALFA Engenharia facilities.

Development of the holographic transmitter during bench tests at Poli/USP.

INVAP joins LLAMA collaboration

As a result of the external evaluation of the project, the government of Argentina invited INVAP to join the development of LLAMA Observatory. INVAP (https://www.invap.com.ar/) is an Argentine state company headquartered in Bariloche, dedicated to the design, construction and integration of plants, equipment and devices in highly complex areas such as nuclear energy, space technology, industrial technology, and medical and scientific equipment.

The company has been working for LLAMA since November 2020 and is in the process of signing a contract with MinCyT, whose scope will be the development necessary to take LLAMA to the so-called first light. In this way, INVAP must act in the development of the site's infrastructure (power supply, communications, civil works) and in the assembly of the antenna and its initial pointing tests, in accordance with procedures established in agreement with VERTEX. Collaboration for the integration of receivers is also expected. The objective is to reach the stage of obtaining calibrated observations of radio sources in spectral (molecular lines) and continuum form. The forecast is for the MinCyT - INVAP contract to be signed between June and July 2021.

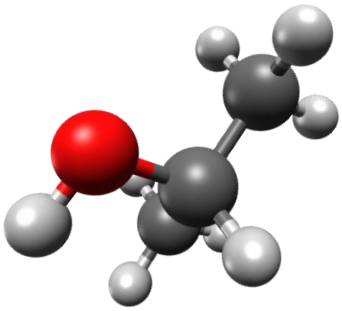
INVAP has already visited the LLAMA site, at Alto Chorrillos, established relationships with VERTEX and is in growing contact with the binational team that has been actively working towards the creation of the observatory over the past few years.

At this moment, INVAP is identifying companies to carry out the works in the unique environmental conditions of the site, including the high altitudes and low relative humidity.

Additionally, INVAP is also starting to work together with the "Dirección de Asuntos Satellitales" (DAS) of the "Subsecretaría de Tecnologías de la Información y las Comunicaciones". DAS is responsible for handling the electromagnetic spectrum in Argentina for radio frequency interference (RFI) and will work with INVAP to gather requirements for the creation of a Radio Quiet Zone (RQZ), following the recommendations and resolutions of the International Telecommunications Union (ITU/UN). This is an important step to provide to the Alto Chorrilos region and surroundings the preservation of its environmental qualities that characterize it as a promising location for the installation of large astronomical projects

INVAP headquarters in Bariloche. Image credit: institutional website.

Science Group Activities



LLAMA has recomposed its Science Integrated Product Team (IPT) – the "Science Group". The team comprises astronomers and engineers from Argentina and Brazil, and has weekly meets since October 2020. The objective is to implement a coherent and mutually agreed vision on how to use the facilities. The re-establishment of the group also responds to the recommendations made by the international panel of evaluation convened by MinCyT.

Among the responsibilities of the science group is the preparation of a document with the science requirements, the development of plans of operations, proposals for time allocation policies, encouraging to the training of human resources for radio astronomy in both countries, the development and management of strategies for LLAMA public communication. The Science IPT is organized into smaller working groups dedicated to the development of specific tasks and documents, which are later extensively discussed and improved with the entire team.

It is important to emphasize that the Science IPT has been working not only in the context of the first light and the scope of the current agreement between Argentina and Brazil, but with a longer-term vision aiming to establish LLAMA as a competitive observatory, in the frontier of scientific and technological development for the observation of the Universe at millimeter/submillimeter wavelengths. Among the first results of the group's activities are the reactivation of this newsletter and the start of LLAMA-IAFE 2021 seminar series, also presented in this edition.

Arrival of the new Yoke Traverse

In 2018, while transporting the antenna from the port of Zárate (Argentina) to the LLAMA site in Salta, one of the trucks suffered an accident (https://bityli.com/7zmSY), in which the Yoke Traverse was damaged.

Taking into account VERTEX's own assessment of the extent of the damage, it was decided that a new part would be built for replacement in Germany, with the costs properly covered by the insurance that was taken out by the Argentine partners for the transport operation.

The new Yoke Traverse was produced and arrived in Zárate in early May 2020. Despite additional difficulties due to the pandemic situation, the complex operation of transporting the part to the site was successfully completed on May 26th. Now, with all the parts together, the expectation is that the assembly of the antenna will take place from the beginning of 2022, after the completion of the construction works of the concrete base, activities that will be carried out under the organization of INVAP.

The new Yoke Traverse arriving at the port of Zárate (Argentina) in May 2020.

NACOS development

The opto-electrical-mechanical system responsible for guiding the light from the primary focus of the antenna to the different cabins and receivers at LLAMA constitutes the NAsmyth Cabin Optical System (NACOS). Although LLAMA's antenna has a Cassegrain cabin and two Nasmyths, for the first light only one Nasmyth cabin (Nasmyth B) is planned, taking into account that only two of the six planned receivers are ensured for the start of operations (bands 5 and 9).

The subsystem was initially designed by Jacob Kooi (JPL, USA; optical and mechanical drawings); Fernando Santoro (Astro-EME, USA; mechanical design); Emiliano Rasztocky (IAR, optical and mechanical drawings) and Carlos Fermino (e-Fe - Industrial Technologies, Brazil, mechanical and electrical drawings). NACOS also houses the robotic arms system with three calibration charges which, in turn, are a development of the University of Concepción (Chile), under the leadership of Rodrigo Reeves.

NACOS is subdivided into two parts: the CASS, mechanical structure for the Cassegrain cabin, which will support the calibration loads, and a mirror system to direct the light to the cabin in operation. The mechanical structure in the Nasmyth cabins (NASS) will include the cryostat where up to three receivers cooled to 4 K (-269 degrees Celsius) will be installed, mounted in the form of interchangeable cartridges.

NACOS' machining was done at ALFA Engenharia (Araraquara, SP, Brazil), and the integration, including optical alignment and automation, continues to be carried out at the company's premises and with the support of its team.

Top: Overview of the NACOS mechanical design. Bottom: NASS and CASS, components of NACOS, in the process of integration and optical alignment in the premises of ALFA Engenharia (Araraquara, Brazil).

Three phases of integration and testing have been completed so far, with the fourth being postponed due to the pandemic. The installation and tests of the calibration loads robotic arms are planned for the pending mission, as well as the tests of the loads themselves. As soon as sanitary conditions allow the entire team to work safely, the fourth phase will be carried out.

In the meantime, the development of the NACOS project continues, aiming to populate the two Nasmyth cabins with more receivers in the future and adapting the Cassegrain cabin to receive new instruments. The work, led by Emiliano Rasztocky (IAR), should involve minor adjustments to the part already machined for the first light, thus optimizing the use of time before the equipment is sent to Argentina for its final installation.

Development status of the receivers

The cartridges of the ALMA-type receivers of band 5 and 9 (157 - 212 GHz; 602 - 720 GHz), as well as the cryostat that will house them, are ready in the Netherlands after development and testing work by NOVA team (Netherlands), together with engineers from Poli/USP; IAR and IAG/USP. These items, which constitute the front-end of the receivers, will be sent to Argentina at the time of integration with the analog and digital processing stage of intermediate frequency signals (4-12 GHz). Some parts of the back-end have already been acquired (an spectrometer, for example) and there are prototypes of some modules whose current level of development is already adequate for LLAMA's first light. New technological solutions to fully exploit the scientific potential of receivers are currently being developed. In particular, in the last months there has been significant progress in the development of a new processor/converter for Intermediate Frequency (FI down convert) by Poli/USP, under the leadership of Fátima Correra.

Furthermore, there are prospects of having a band 6 receiver available through a new collaboration with NOVA and the BRICS countries. Together with researchers from the University of Chile and the Chinese Academy of Science, South America Center for Astronomy (CASSACA, a Chinese institution with headquarters at the University of Chile), efforts are being started for the development of a 2+3 band receiver, under the leadership of Ricardo Finger (University of Chile).

Receivers in the frequency bands of the 2+3 and 6 (67 – 116 GHz; 211 – 275 GHz) are fundamental for the future participation of LLAMA in VLBI experiments.

Holography System

Holography is the technique used to align the 264 aluminum panels that make up the antenna dish. In the case of LLAMA, the near-field approach will be applied, in which a transmitter is positioned on top of a tower (at a total height of about 60 meters), approximately 360 meters away from the radio telescope. The antenna will be delivered by VERTEX with dish surface accuracy of 25 μm rms and the aim of the work with the holography system is to improve it and keep it between 15 and 20 μm rms.

For the task, a receiver obtained as a loan from the NRAO will be installed in the position of the antenna sub-reflector. The receiver for holography has two horns for incident radiation, but on opposite sides: one horn receives the incident radiation directly from the transmitter, and the other receives the radiation emitted by the transmitter and reflected by the antenna dish. The surface quality of the dish is inferred by comparing the phase difference of the radiation incident on the two horns.

The 104.2 GHz transmitter is being developed and built by engineers from Polytechnic School of USP (Brazil), under the leadership of Fátima Correra. The equipment will feature thermal stabilization, remote monitoring and control, using a fiber optic link with the antenna control room, and will be housed in a weatherproof box.

A key point is the transmitter horn which, due to its strict requirements, is a specific development work in collaboration with the University of Chile and NOVA (Netherlands). As of this writing, the horn has already been machined and is undergoing characterization and testing in the Netherlands.

Seminar Cycle LLAMA-IAFE 2021

In 2021, on the initiative of the "Instituto de Astronomía y Física del Espacio" (IAFE, Argentina), we are starting a series of monthly meetings to present and discuss scientific projects related to LLAMA. The objective of the meetings is to familiarize the astronomical communities of Argentina and Brazil with the full potential of LLAMA, in order to encourage the articulation of scientific projects for the new radio observatory.

Seminars take place on the first Friday of the month, at 10:00 am (GMT-3), and with the following structure:

- Seminar on topics directly related to the development of LLAMA - 40 minutes;
- Discussion - 10 minutes;
- Break - 15 minutes;
- Seminar about scientific subjects in radio astronomy - 20 minutes;
- Seminar about a general theme (focusing on observational astronomy) - 20 minutes;
- Discussion and closing - 10 minutes.

We invite all to the cycle's opening seminar, which will take place on June 4, 2021. Online participation in the seminars will be carried out through the Zoom platform. The link and access instructions will be widely publicized in advance.

The updated schedule for the entire seminar cycle can be followed at:

https://www.llamaobservatory.org/seminars2021/

Organizing Committee: Silvina Cichowolski (IAFE, Argentina) - scicho@iafe.uba.ar; Carlos Valotto (OAC, Argentina); Germán Cristiani (IAFE, Argentina); Laura Suad (IAFE, Argentina) and Nicolás Duronea (IALP, Argentina).

Reading Recommendations

We leave here the suggestion of an article related to topics of interest to the future LLAMA scientific users community.

Interrelations Between Astrochemistry and Galactic Dynamics

Mendoza E., Duronea N., Ronsó D., Corazza L.C., van der Tak F., Paron S. and Nyman L.-Å. (2021). Interrelations Between Astrochemistry and Galactic Dynamics. Front. Astron. Space Sci. 8:655450.

https://doi.org/10.3389/fspas.2021.655450

Abstract: This paper presents a review of ideas that interconnect astrochemistry and galactic dynamics. Since these two areas are vast and not recent, each one has already been covered separately by several reviews. After a general historical introduction, and a needed quick review of processes such as stellar nucleosynthesis that gives the base to understand the interstellar formation of simple chemical compounds (e.g., H_2, CO, NH_3, and H_2O), we focus on a number of topics that are at the crossing of the two big areas, dynamics and astrochemistry. Astrochemistry is a flourishing field that intends to study the presence and formation of molecules as well as the influence of them on the structure, evolution, and dynamics of astronomical objects. The progress in the knowledge on the existence of new complex molecules and of their process of formation originates from the observational, experimental, and theoretical areas that compose the field. The interfacing areas include star formation, protoplanetary disks, the role of the spiral arms, and the chemical abundance gradients in the galactic disk. It often happens that the physical conditions in some regions of the interstellar medium are only revealed by means of molecular observations. To organize a rough classification of chemical evolution processes, we discuss about how astrochemistry can act in three different contexts, namely, the chemistry of the early universe, including external galaxies, star-forming regions, and asymptotic giant branch (AGB) stars and circumstellar envelopes. We mention that our research is stimulated by plans for instruments and projects, such as the ongoing Large Latin American Millimeter Array (LLAMA), which consists in the construction of a 12m sub-mm radio telescope in the Andes. Thus, modern and new facilities can play a key role in new discoveries not only in astrochemistry but also in radio astronomy and related areas. Furthermore, the research on the origin of life is also a stimulating perspective.