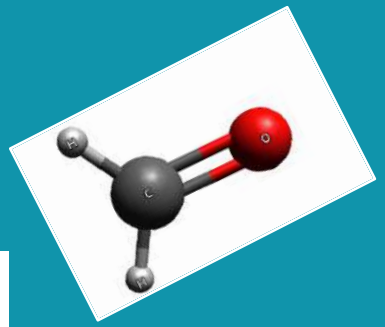
The LLAMA Project

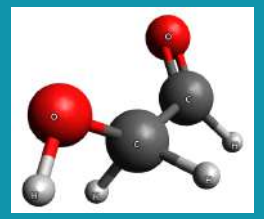
Radiotelescope in the Argentinian Andes
At 4800 m atitude

FAPESP
CNPq
LLAMA
Ministerio de Ciencia, Tecnología e Innovación Argentina
GOBIERNO DE SALTA
CONAE
USP Universidade de São Paulo
INPE
Universidade Presbiteriana Mackenzie
IAFE CONICET UBA
IAR CCT La Plata CONICET
OAC 150
ALFA FERRAMENTARIA
INVAP

Some scientific possibilities of LLAMA

Solar Radio Astronomy (LLAMA can be pointed to the Sun)





Astrochemistry - discovery of new molecules

Star formation regions. Observation of velocity fields, temperatures, densities

Extragalactic Megamasers H2O . Megamaser transition at 183 GHz: searh for new sources and monitoring

Variability of Active Nuclei of Galaxies

High resolution observations using VLBI for instance of Black Holes

Context

ALMA is the most important instrument o f the world in millimetric radio astronomy, officially **concluded in March 2013** . It is a collaboration between USA, Europe and Japan. Situated in the Atacama desert, in the North of Chile, at 5000 m altitude.

66 antennas of 12 m diameter, operating in frequency bands from 100 GHz to 800 GHz

Spetacular results are being obtained by ALMA since then.

APEX was contructed by the same company VERTEX which later constructed LLAMA LLAMA and APEX have similar aspects, with 2 Nasmyth cabins

APEX


Lago Titicaca
Trinidad
Cuiaba
Brasilia
Arequipa
BOLIVIA
La Paz
Santa Cruz
Brazil
Goiania
Montes Clare
Tacna
Arica
Sucre
Corumba
Uberlandia
Belo Horizonte
Iquique
Campo Grande
Tarija
Paraguay
Parana
Ribeirao Preto
Campinas
Sorocaba
Rio de Ja
Antofagasta
PARAGUAY
Sao Paulo
Salta
Asuncion
Ponta Grossa
Ciudad del Este
Formosa
Curitiba
Posadas
Copiapo
San Miguel de Tucuman
Florianopolis
Parana
Uruguay
La Serena
Caxias do Sul
Porto Alegre
CHILE
San Juan
Córdoba
Santa Fe
Pelotas
Valparaiso
Mendoza
Rosario
URUGUAY
Santiago
Durazno
Buenos Aires
Montevideo
Santa Rosa
Concepcion
ARGENTINA

Historical main steps

- 2011-2013 Workshop organized by FAPESP to approve the LLAMA project & proj. approved
- 2014 Agreement FAPESP-USP- MinCyT (Argentina) signed ; roles of partners defined
- 2014 start of the antena construction by VERTEX Antennentechnic GmbH
- 2014- Final choice of the site at Alto Chorillos
- 2015-2017 decisões sobre receptores, organização do espaço dentro da antena;
- 2018-2019 crise administrativa e financeira do lado argentino.

Situation after 2019

- 2020 MinCyT organizes an internacional pannel of 6 scientists to re-evaluate the LLAMA Project (to decide if it is still Worth continyuing it after so many delays n the construction. The answer was cleary :yes. LLAMA is still a competitive project
- 2021: Argentina decides to engage **INVAP**, an important public company, to provide the infraestruture, and to mount the antenna , until it reaches the “first light” detection
- 2022-2023 LLAMA re-births, with new enthousiasm os the participants; an agreement of INVAP with VERTEX is reached, VERTEX will provide supervision for the mounting.

- 2024: **a total desaster!** The Milei government decides to stop the mounting of LLAMA

The LLAMA reflector, constructed by VERTEX, was in the process of been mounted by INVAP, on the site of the observatory, in Alto Chorrillos, when the order to stop the work came. Since then the reflector is precisely at the same place, with no protection.

Argentinean tasks

- infrastructure of observatory, concrete base to mount antenna on, power energy supply , telecommunication system, building + control room, tower to install holography , etc
- Antenna mounting: consist in assembling the parts that were sent in containers by VERTEX
- The multichannel 128 channels spectrograph for spectral line observations acquired by Argentina

Brasilian tasks:

- Follow and pay the construction of antenna by VERTEX in Duisburg (Germany)
- Administrate design , fabrication or purchase of systems to be installed in the antenna
- - Cooled receivers and cryostats, Helium 4K refrigeration, Band 5: 162-211 GHz Band 6: 211-270 GH z Band 9 : 602-720 GHz

  - back-end , with frequency filters, IF amplifirers
  - Data acquisition and data storage hardware
  - System for antenna pointing verification and adjustment with **optical telescope**
  - System for adjustment of the positions of the pannels of the main dish **(holografy**)

Tasks shared by the two countries. Software for control of the antenna pointing, data acquisition, data transmission

Members of the Brazilian LLAMA team

• Jacques Lépine	Coordinator	IAG-USP
• Carlos Guillermo Giménez de Castro	Executive Committee	Mackenzie University
• Fátima Salete Correra	Executive Committee	Politecnica USP
• Ciriaco Godi	Executive Committee	IAG-USP
• Jane Gregorio-Hetem	Executive Committee	IAG-USP
• Elisabete de Gouvea Dal Pino	Executive Committee	IAG-USP
• Antonio Sandro Verri	Engineer	Politécnica-USP
• Danilo Zanella	Physicist	IAG-USP
• Marcos Aurelio Luqueze	Engineer	Politécnica-USP
• Wesley Beccaro	Engineer	Politécnica-USP

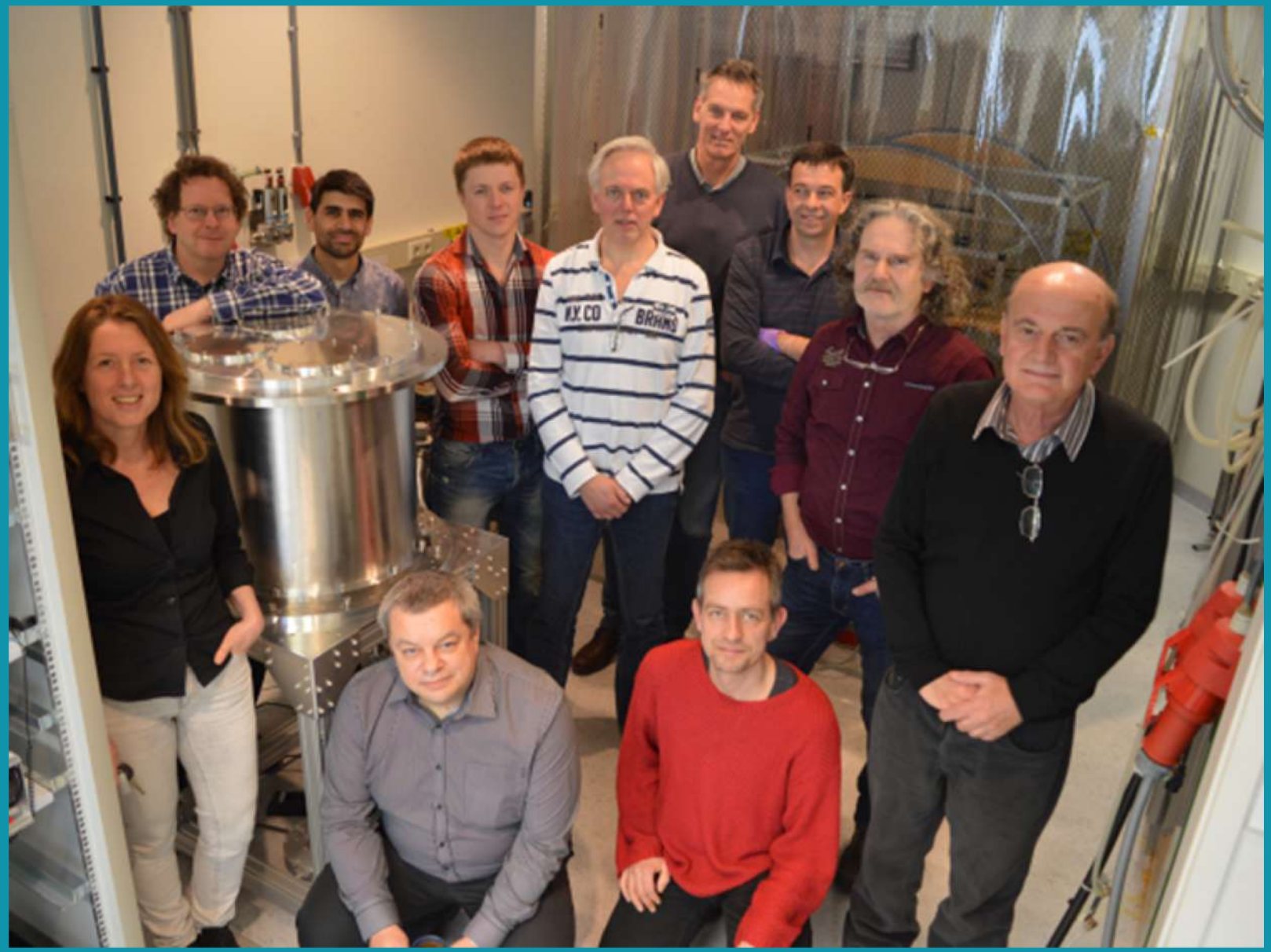
Main collaborators: Thijs de Graauw Juan José Larrate Juan Pablo Garcia Jacob Kooi Carlos Fermino, Augusto Uemura, Ricardo Finger Andrey Baryschev Fernando Santoro Emiliano Rasztoky Rodrigo Reeves Shinichiro Asayama Sjoerd Themba Timmer

NOVA Groningen

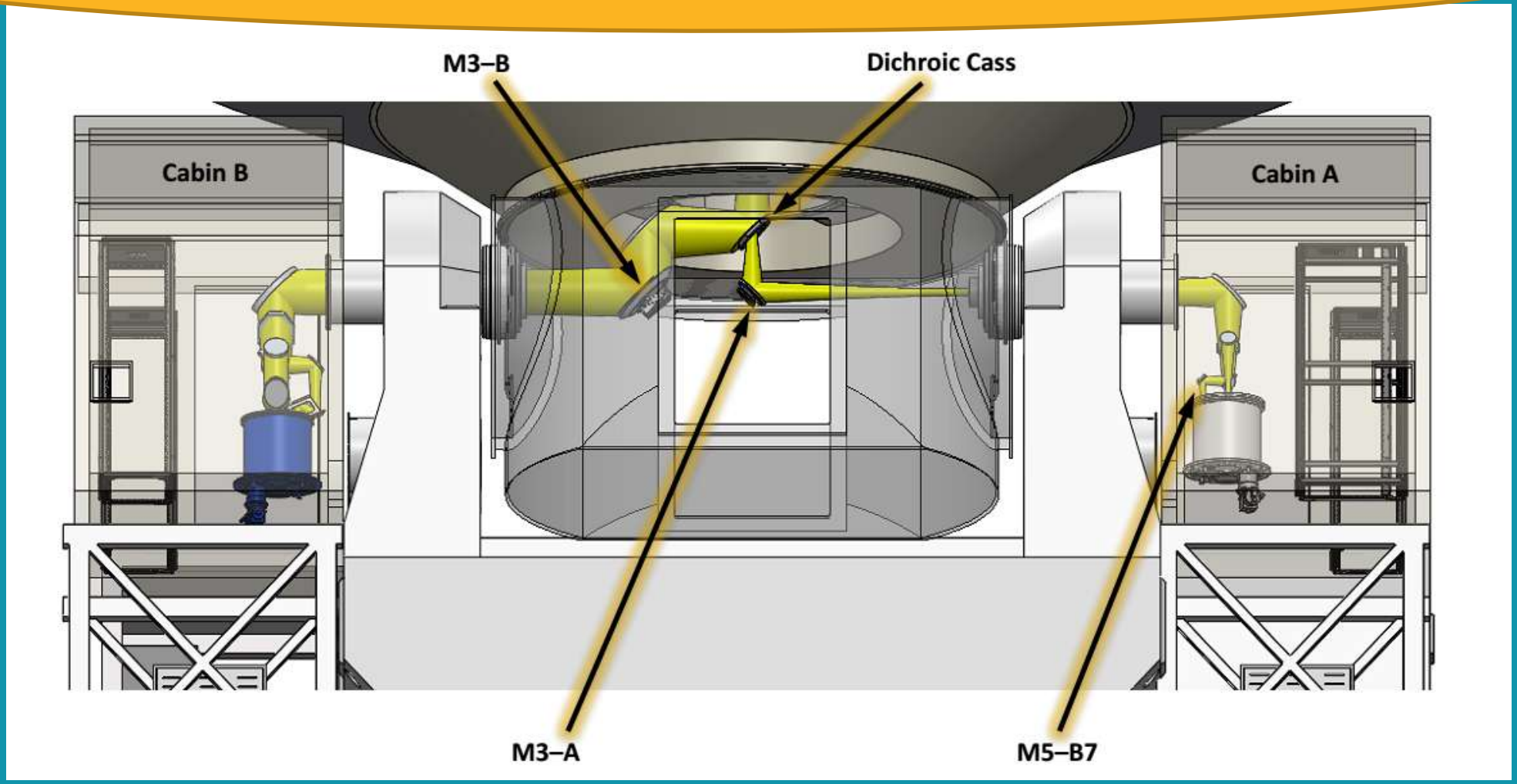
One of the best Teraherz labs in the world , which was responsible of the construction of the band 5, band 6 and ban 9 receivers for LLAMA

One can see our cryostat (constructed in Japan), and there are 2 engineers from São Paulo Uiversity and one Argentinian engineer from IAR

With grey shirt , on the front, is Andrey Baryschev, responsible for the lab

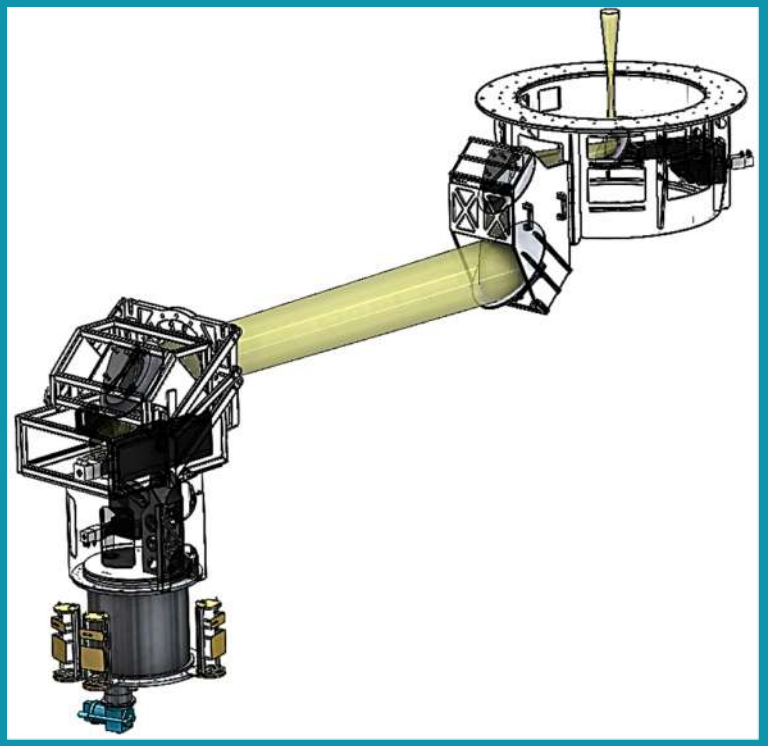


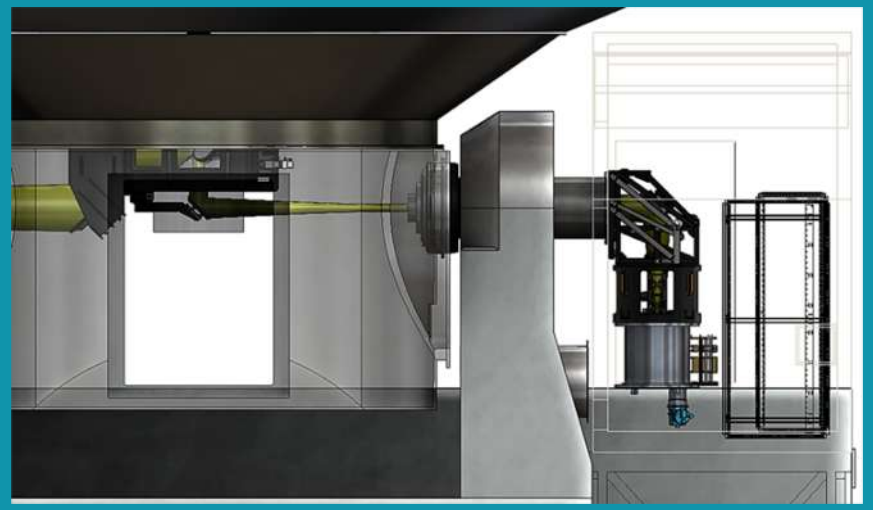
The Cassegrain cabin and the two Nasmyth cabins, one on each side. The cryostats for the receivers can be seen in the Nasmyth cabin. The yellow color represent the path of the microwave beam. The project has been modified . Only one cryostat has been constructed



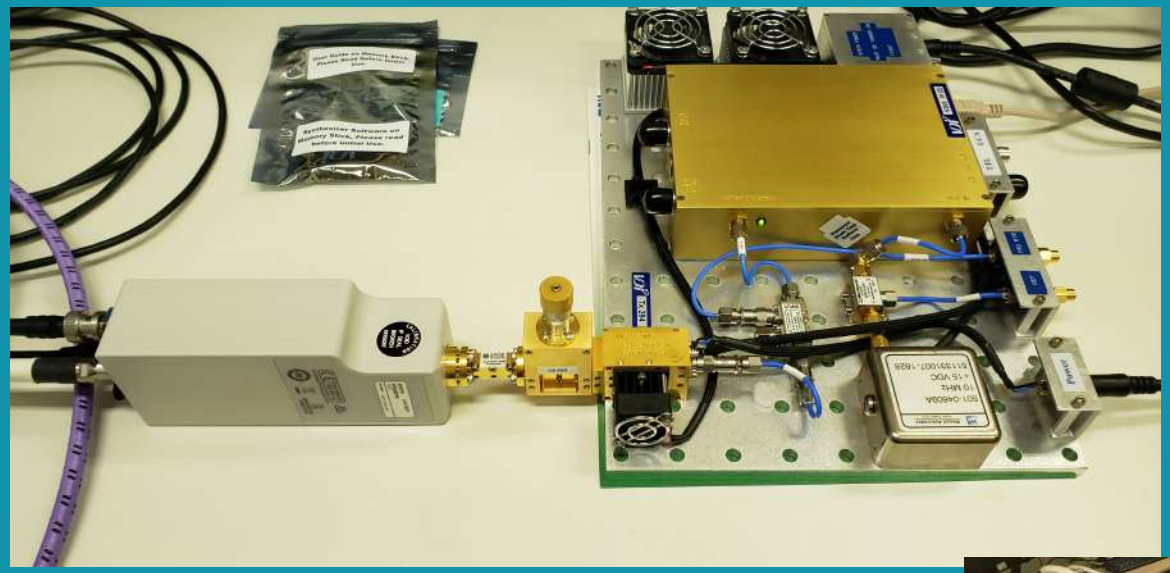
Main pieces CAS and NAS , now constructed , tested and packed , ready to be sent to Argentina. First design was made by ASTRO Electro-Mechanical Engineering LLC EUA, based on ideas of Jacob Kooi . The construction of all the pieces was made by ALPFA Ferramentaria , a metallurgic company located in Araraquara, São Paulo State

criostato

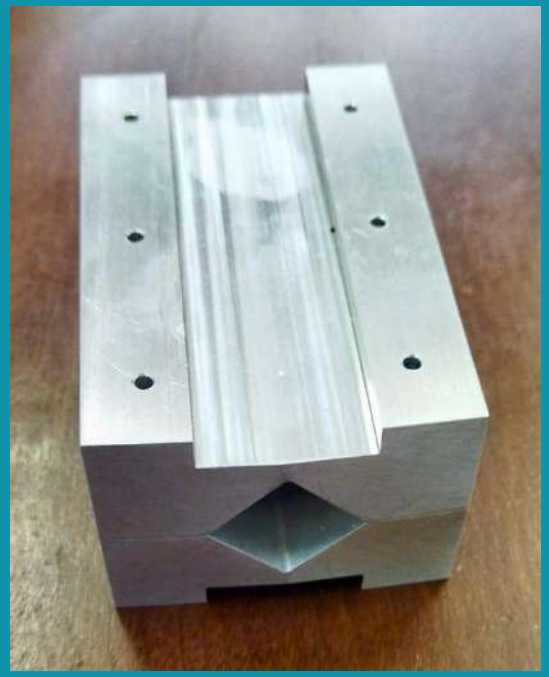




Transmitter of 104 GHz radiation for the Holographic System to be used to adjust the position of the pannels of the antenna dish
Mounted by LME group at Escola Politecnica, USP



Horn antenna of the 104 GHz transmitter of holography system (IAG/NOVA)



Optical telescope and CCD camera to be mounted in the LLAMA dish to check and correct the pointing using visible stars

LLAMA pieces constructed by Alfa Ferramentaria, Araraquara, São Paulo State

In yellow the auxiliary
Mechanism projected
by Emiliano Rasztocky
To introduce CAS in the
Cassegrain cabin which
has a narrow dor

Enthousiam in Alfa Ferramentaria to have completed NAS and Cas

ALLAM 2019

Astrochemistry LLAMA Meeting

Topics

- Observational Astrochemistry
- Astrochemistry with LLAMA
- Astrochemistry in the Laboratory
- Theoretical and Computational Astrochemist
- Astrochemistry and the Origin of Life

International meeting in Salta In 2022

ale | **Speakers** | **Program** | **Registration** | **Committees** | **Venue**

- Dr. José Cernicharo - Instituto de Física Fundamental, Spain;
- Dr. Kate Pattle - University College London, UK;
- Dr. Paul Ho - Academia Sinica Institute of Astronomy and Astrophysics, Taiwan;
- Dr. Stan Kurtz - Instituto de Radioastronomía y Astrofísica, Mexico;
- Dr. Steven Mairs - NASA Ames Research Center, USA;
- Dr. Thibault Cavalie - Laboratoire d'Astrophysique de Bordeaux, France;
- Dr. Kazumasa Iwai - Nagoya University, Japan;
- Next generation Event Horizon Telescope lecturer - ngEHT Global Collaboration

Dr. Sheperd Doeleman - Harvard University,

Plans for future

1) To plan the integration and tests of cryostat and band 9 and band 5 receivers in Argentina. The difficulty, for us, is that the Argentinian side has not taken a decision, to my knowledge, whether this will take place at IAR or at Salta. Another problem is that we would like to perform the integration and test of the band 6 receiver at the same epoch. However, we still have to purchase the warm components made by NRAO for this receiver. Note that the warm components of the other 2 receivers (band 5 and band 9) were purchased by us (IAG) from NRAO a few years ago. Nova does not have the capability of constructing this for us. Only recently we started negotiations wih NRAO concerning this last set of warm components

2) We are planning to send the NAS and CAS equipment, including the auxiliary equipment which has also been constructed at Araraquara, only for mounting the NAS and CAS inside the telescope. The robotic arm ans calibration loads for calibration of the signal of the receivers, the mirrors, and the electronic systems to control the position of the mirrors are all to be sent together.

3) All this material has to be sent by truck to Salta or even to the site of the observatory. To pass at La Plata would be nonsense. To perform the mounting we will send 3 persons: Emilianp Rasztocky, Carlos Fermino, and a technician from the factory in Araraquara who is small and is able to enter inside the NAS and CASS structures to mount them.
We would like to have the help of one person from INVAP who knows the site and may help us in the logistics and providing the simple tools that will be used.

4) To conclude the mounting and testing of the holographic system which is presently being constructed by the group Fatima at the Escola Politécnica, to adjust the panels of the dish and to reach at list 15 microns rms.

5) We have to proceed the discussions with Ricardo Finger, who is constructing a band 2 + 3 receiver, to be used in LLAMA, that will be installed in the Cass cabin as a first solution

6) On a slightly longer term, we would like to mount a second NAS system to populate the cabin that is being left empty for the moment.. This will be an unavoidable task if we wish to perform simultaneous observations at two frequencies in futures

Resumo das 6 solicitações encaminhadas pelo IAG ao lado argentino:

1) Planejar integração e testes do criostato e receptores nas bandas 9 e 5 (lado argentino precisa definir o local IAR ou Salta). O ideal seria realizar junto com o de banda 6, mas falta adquirir os componentes warm feitos pelo NRAO.

2) Enviar equipamentos sendo construídos em Araraquara, para a montagem do NAS e o CAS no telescópio. Todos componentes devem ser enviados em conjunto.

3) O transporte de todo material para o sítio do observatório deve ser por caminhão. Além de 3 técnicos que serão enviados para a montagem, será necessário o apoio de uma pessoa da INVAP que conheça o sítio e forneça apoio logístico.

Desafios que se apresentam

- Dar continuidade na montagem da antena é crucial, por questões técnicas (evitar degradação do que já está pronto) e políticas (demonstrar o potencial do LLAMA para o governo argentino);

- Apesar das incertezas de financiamento argentino, a INVAP continua se dedicando ao LLAMA, mas depende dos trabalhos da VERTEX;

- VERTEX solicita $38400 euros para atuar nas próximas 3-4 semanas → o pagamento requer assinatura de contrato. O setor de contratos internacionais da Fapesp pode assessorar?

Propomos estabelecer contratos de curto prazo, para as tarefas imediatas. Dados os riscos, o ideal é avançar passo a passo no cronograma e engajar a VERTEX por missão.

- Membros do LLAMA na Argentina, solicitam envio de representantes brasileiros para negociações com a atual Secretaria de Inovação, Ciência e Tecnologia.