FAPESP
SÃO PAULO RESEARCH FOUNDATION

SPAnet
Rede Paulista de Astronomia

Ministerio de Educación, Cultura, Ciencia y Tecnología
Presidencia de la Nación

LLAMA

LLAMA Radio Observatory

An Overview

Tânia P. Dominici
on behalf of LLAMA Collaboration
https://www.llamaobservatory.org/

IAG
INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS

iar

USP
Universidade de São Paulo

INPE

Universidade Presbiteriana Mackenzie

Outline

- What is LLAMA?
- Site and its status;
- Organization of the project;
- Main Subsystems;
- Some obstacles and possible solutions;
- Perspectives.

LLAMA stands for:
Large Latin America Millimeter/submillimeter Array

2004 – Start of site search → 2009 – Project presented by Lépine & Arnal at IAU GA → 2011 – Project declared priority by Argentina → 2012 – Positive evaluation by FAPESP → 2014 – Signed the agreement BR-AR

APEX
(Chajnantor, Chile)

Initial configuration of LLAMA Observatory:

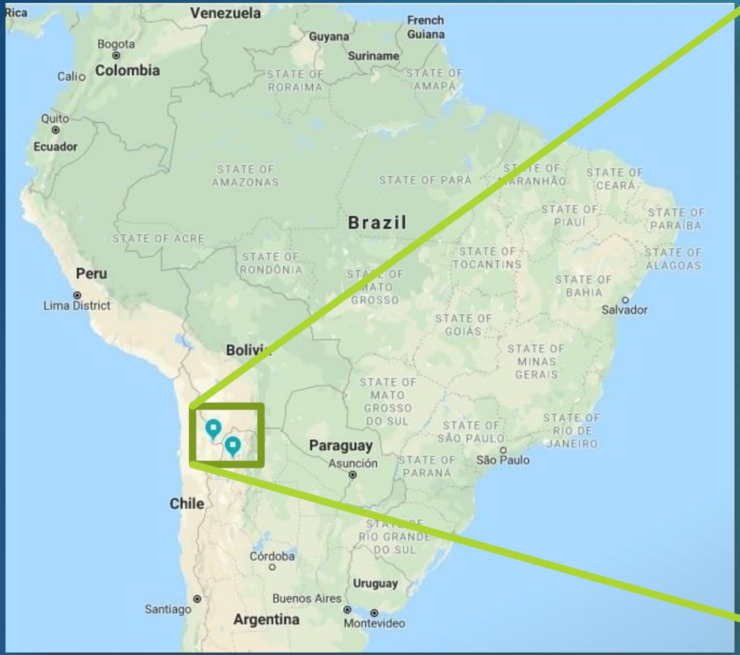
- 12m antenna by VERTEX (Germany);
- Two Nasmyth cabins, similar to APEX;
- ALMA-type receptors at bands 5 and 9 in a cryogenic chamber;
- Pointing precision < 2 arcsec;
- Surface better than 15 μm;
- Spatial resolution: 3’ (35GHz) – 9’’ (700 GHz).

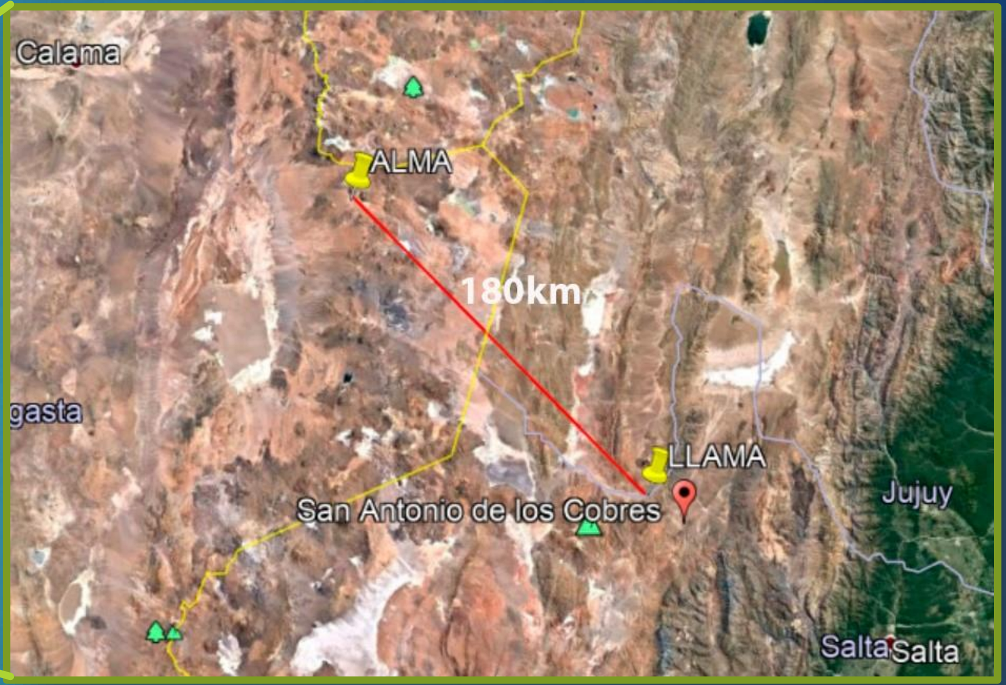
Array? -> Long term project to have a second antenna in the same site.

Site – Alto Chorrilos

4800m high, 16km from SAC; 180km from Chajnantor

- Selected by IAR, in a search that took six years of work.





Similar conditions of Chajnantor (Chile; ALMA and APEX site).

Status of the site (October, 2019)

• Site will be shared with QUBIC (Q&U Bolometric Interferometer for Cosmology; http://qubic.in2p3.fr).

Headquarters at Santo António de Los Cobres

3700m high.

- Remote operations;
- Laboratories;
- Offices;
- Accommodation for scientists and technicians.
- Visitor center?

- Possibility to share QUBIC's facilities at Salta (1100m high).

Organization

2014: Agreement between FAPESP; USP and MinCyT; IAR.

It was valid until mid-2019.

No longer exist.

- Brazilian responsibilities: antenna acquisition;
- Argentinean responsibilities: site infrastructure.

Equivalent financial investment.

Since August 2019, new Steering Committee.

Argentina

- Alberto Etchegoyen (SEGCTIP) - Director;
- Silvina Cichowolski (IAFE);
- Manuel Fernández López (IAR);
- Sergio Parón (IAFE);
- Leonardo Pellizza (IAR);
- Carlos Valotto (CONICET).

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

APEX has been demonstrating the scientific potential of a single dish operating in a extraordinary site for millimeter/submillimeter wavelengths.

→ Telescope pressure ~3 for ESO observing time (32% of the total).

→ The antenna is fully occupied with a varied set of instruments.

In the future, LLAMA can be used in interferometric observations with ALMA and be included in networks as EHT and VLBI.

Some areas to be benefited:

- Black holes and their accretion discs;
- Molecular evolution of the Universe and its connection with astrobiology;
- The spiral structure of the Galaxy;
- Search for counterparts of gamma-ray sources detected with the future array of Cherenkov telescopes (CTA - Cherenkov Telescope Array);
- The Sun – APEX cannot observe the Sun, LLAMA can!

Main subsystems (Instrumentation)

→ Start of operations.

- Optical Telescope;
- Holography;

} Antenna acceptance; Assembly, Integration and Verification (AIV) phase.

→ Talks by Beaklini and Correra.

- NAsmyth Cabin Optical System - NACOS;
- Calibration Loads;
- Cryostat and receivers (bands 5 and 9);

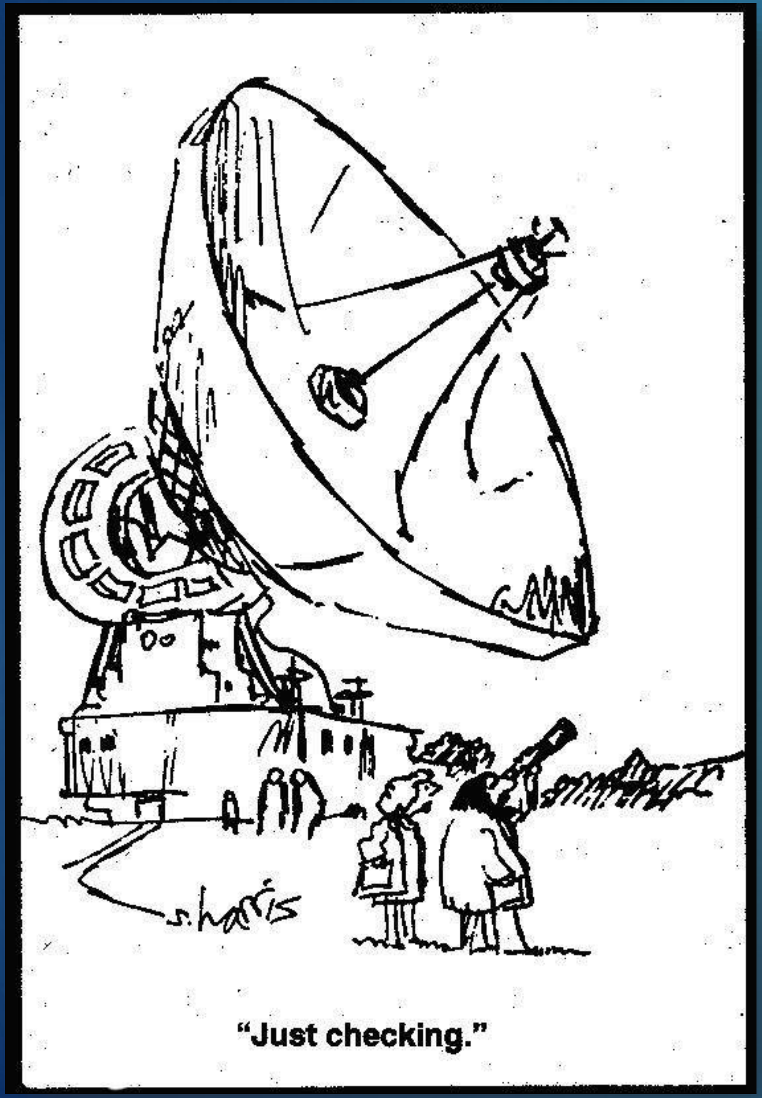
} Commissioning and Science Verification (CVS).

- Software.

→ Talk by Zanella.

Subsystem

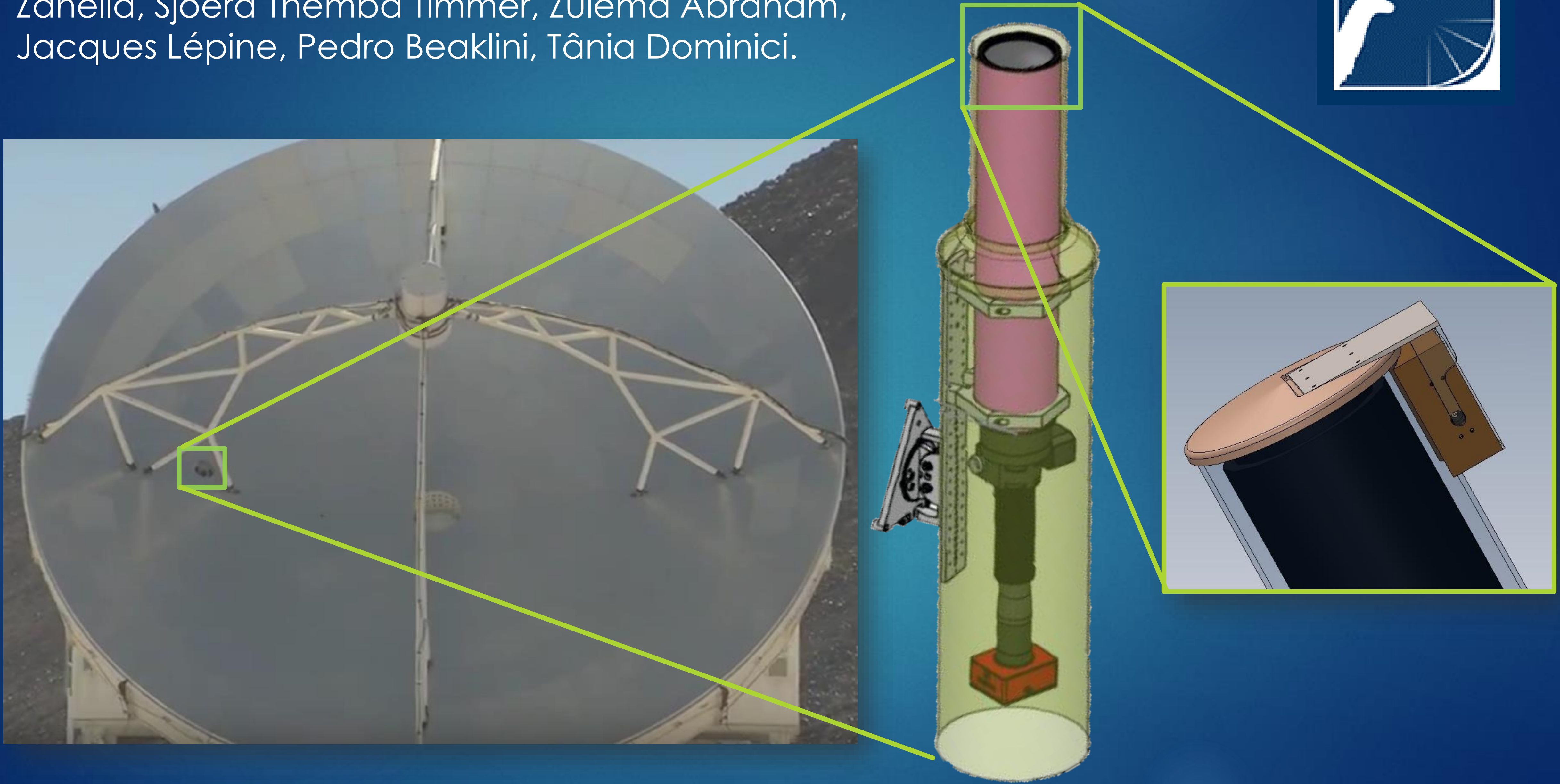
Optical Telescope

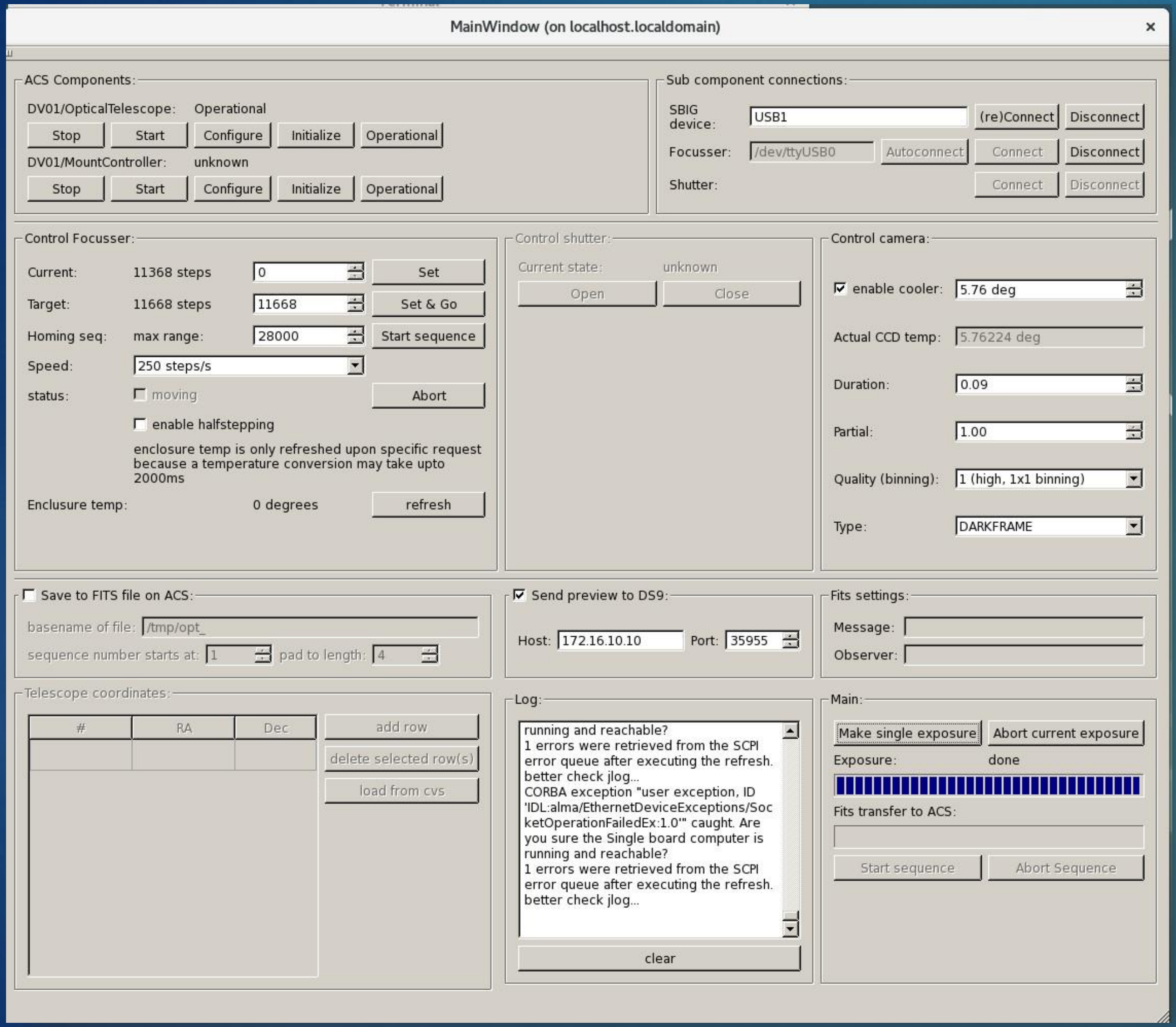


Why do we need an optical telescope for a radiotelescope?

- For acceptance of the antenna.
  - → Receivers are not available at the first moment.
- Few strong sources at millimeter/submillimeter.
  - → Optical observations offers initial values for constants of the pointing model.
- As a maintenance tool, optical observations can help to detect telescope tracking issues.

OPTS team: Luiz Reitano, Daniele Ronsó, Danilo Zanella, Sjoerd Themba Timmer, Zulema Abraham, Jacques Lépine, Pedro Beaklini, Tânia Dominici.





Control software (Themba, Zanella)

- Integrated control of the CCD camera and focus position.

Subsystem

Holography

Technique for measuring and improving antenna surface quality.

→ See talks by Fatima Correra and Pedro Beaklini.

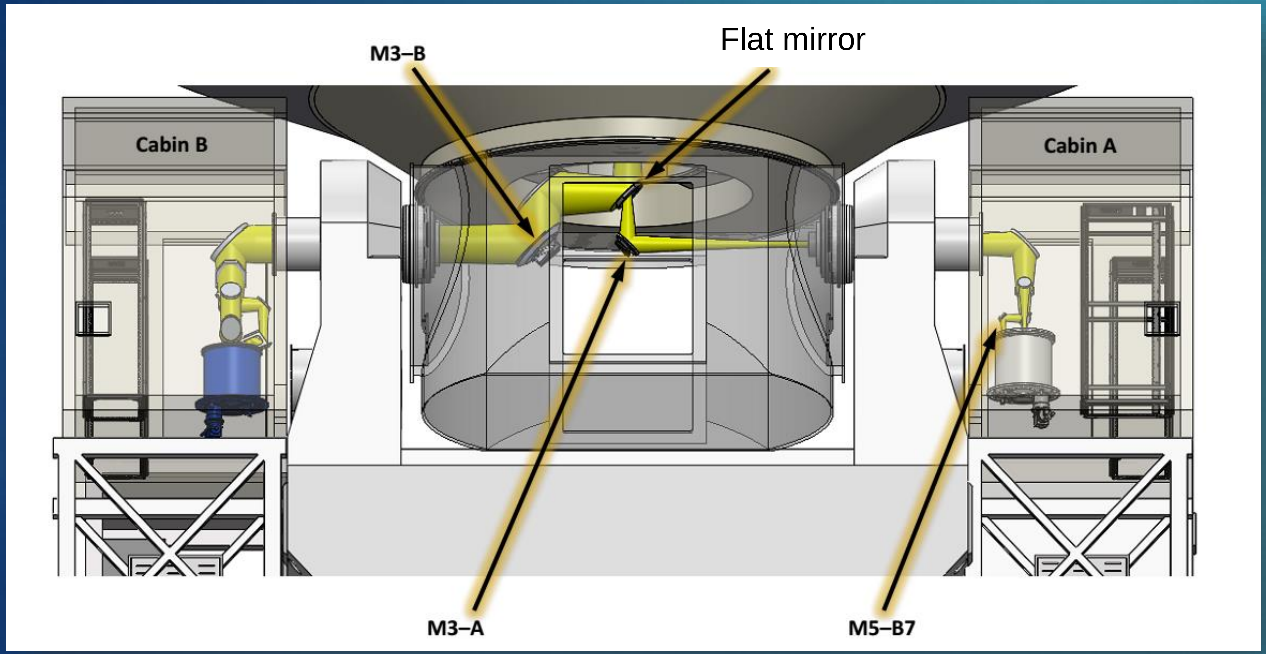
Baars et al. (2007)

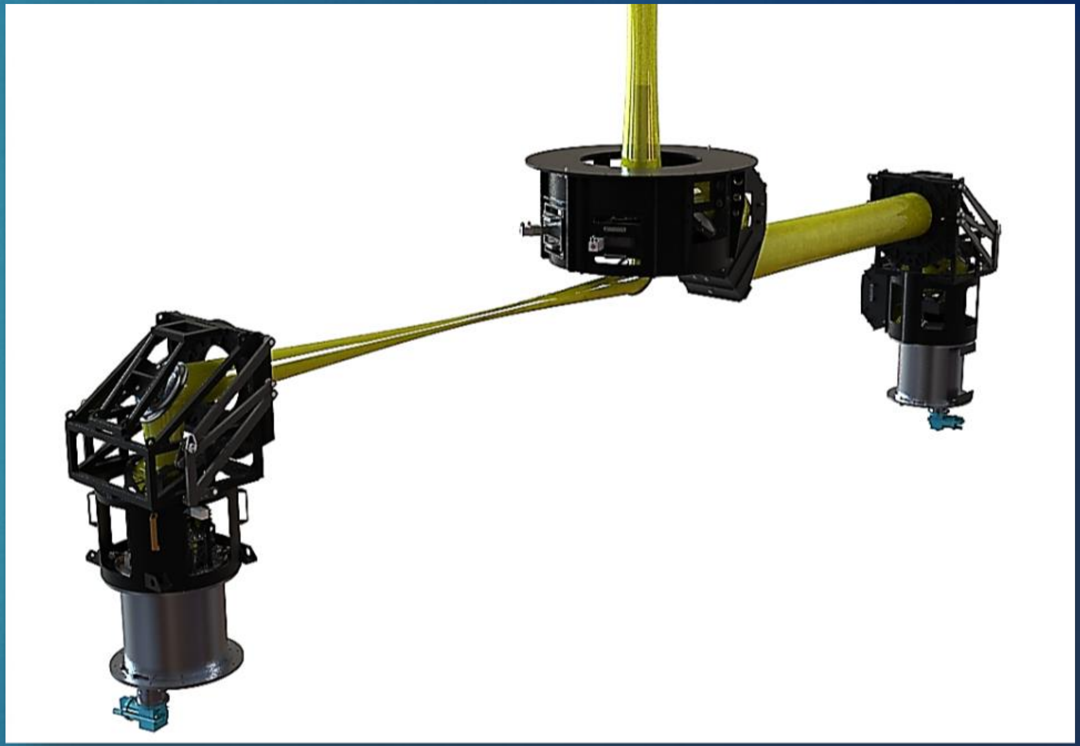
Holography team: Fatima Correra, Sandro Verri, Marcos Luqueze, Wesley Beccaro, Jacques Lépine, Zulema Abraham, Pedro P.B. Beaklini, Daniele Ronsó, Danilo Zanella, Luiz Reitano, Tânia Dominici.

Subsystem

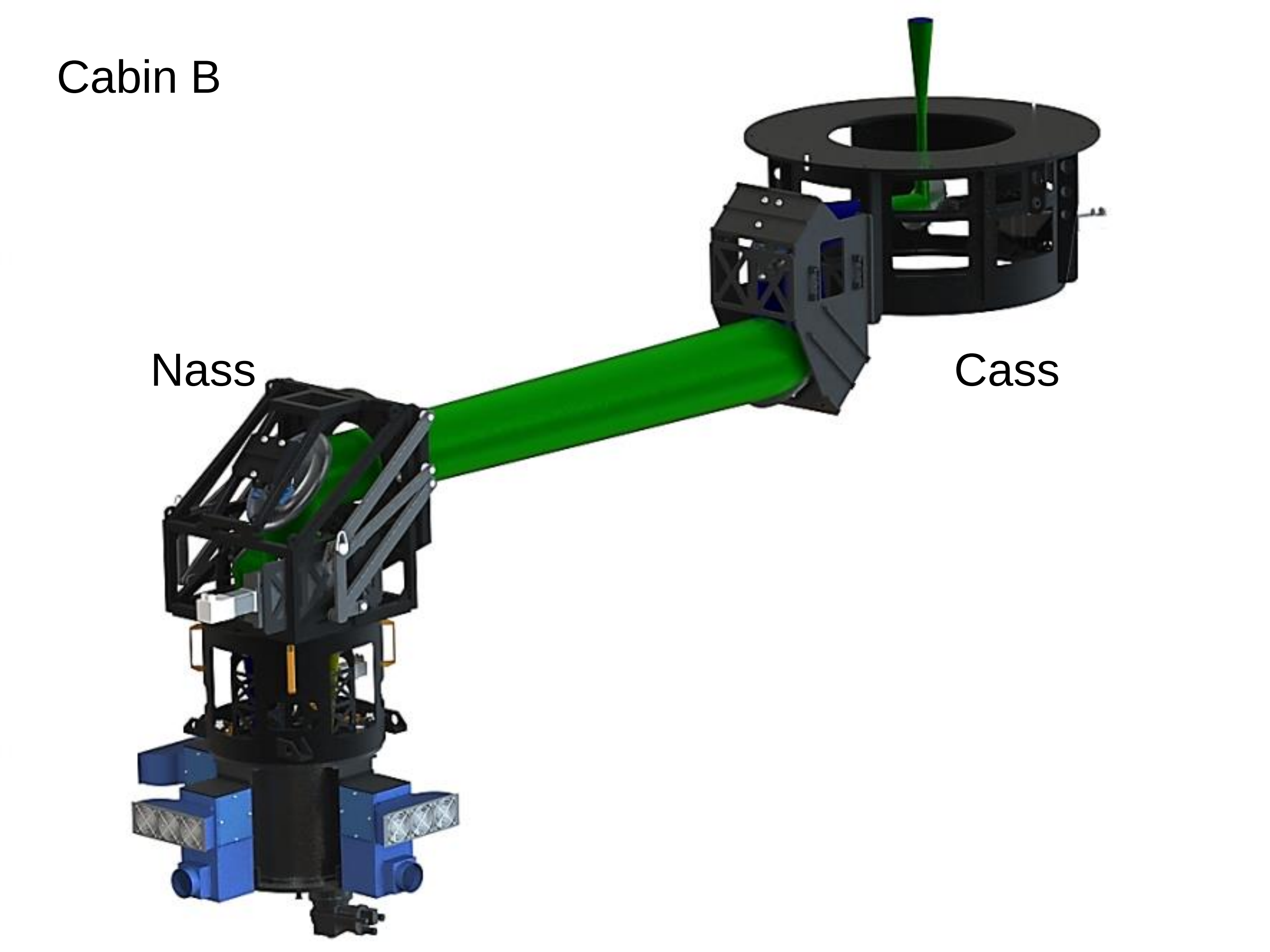
NACOS (NAsmyth Cabin Optical System)

Opto-electrical-mechanical solution to guide the light for different cabins and receptors.





NACOS development team: Jacob Kooi, Emiliano Rasztocky, Jacques Lépine, Carlos Fermino, Fernando Santoro, Danilo Zanella, ALFA Ferramentaria.



Considering that we have two receptors (and one cryostat with three spots), it was decided to populate only Cabin B for the start of operations.

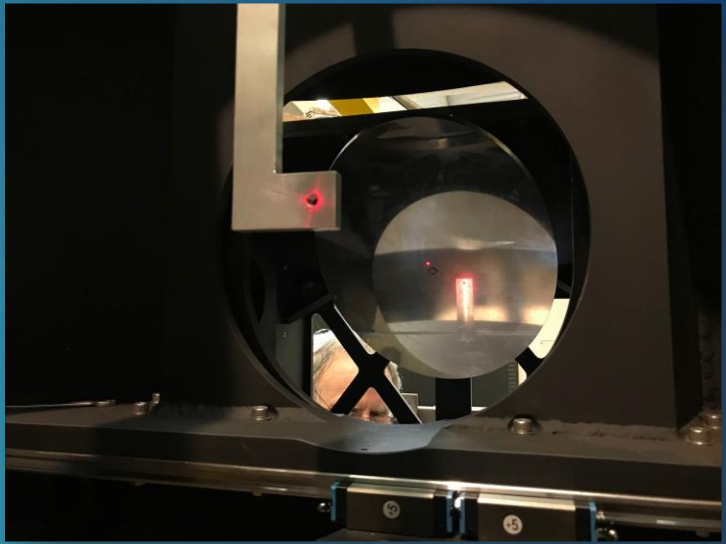
Machining, integration and alignment of NACOS at ALFA Ferramentaria (Araraquara, SP).

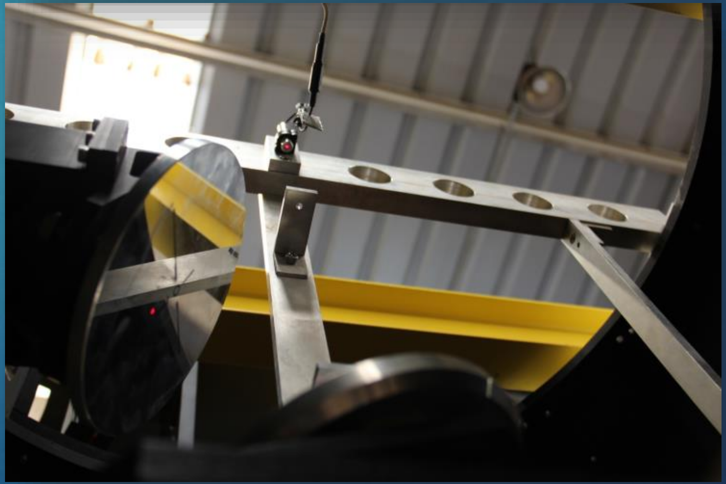
CASS

NASS

Handling/installation carts were designed and machined.

Start of the optical alignment work.





Robotic arms for the calibration loads.

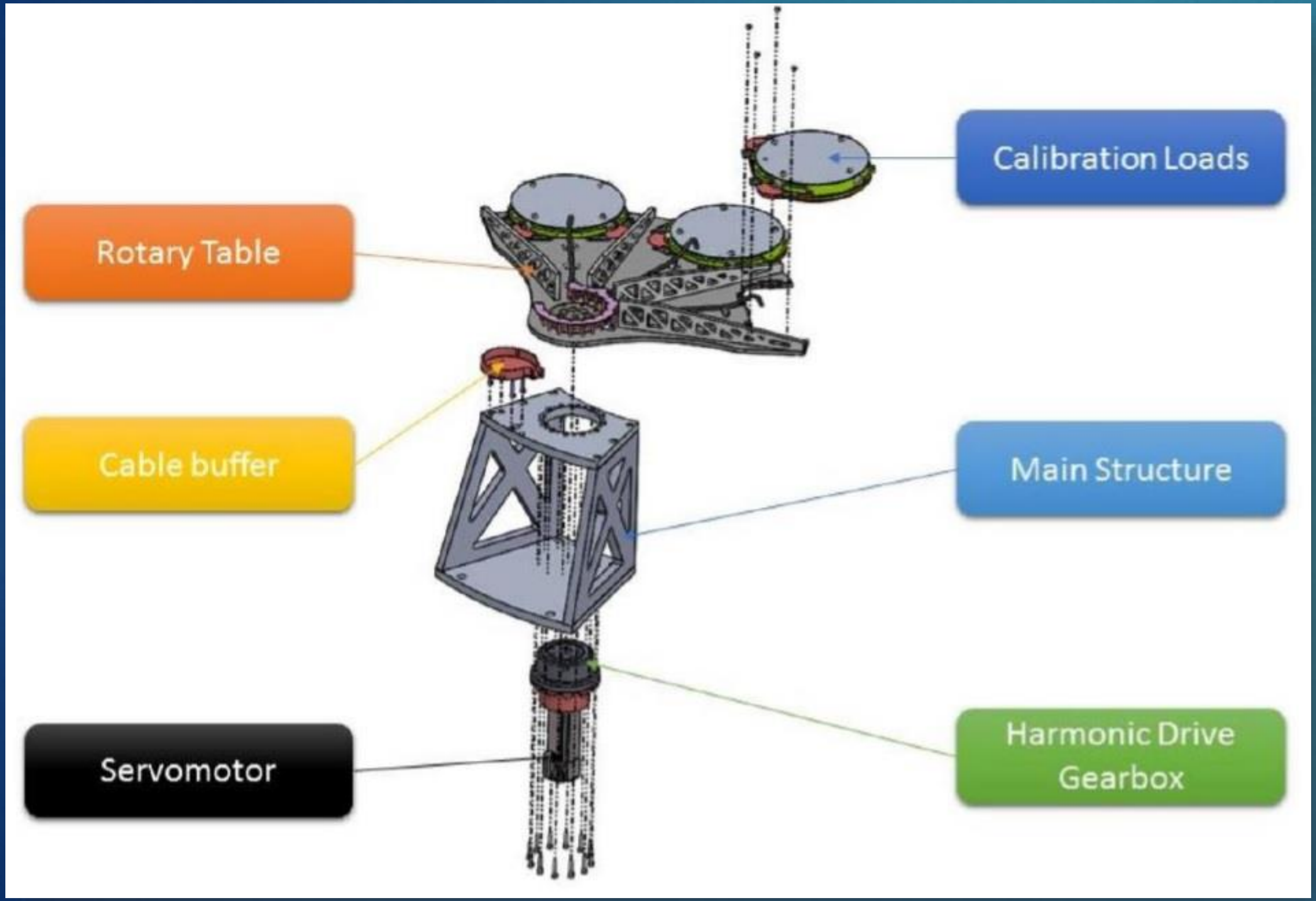
Subsystem

Calibration loads

Development team: R. Reeves et al.

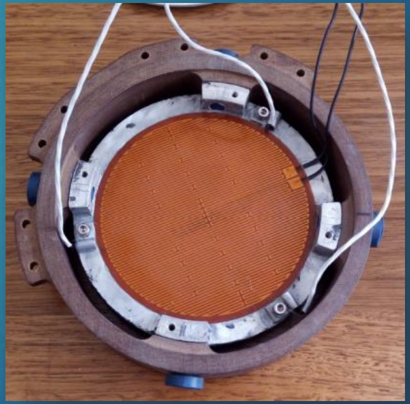
Universidad de Concepción

LLAMA



Three calibration loads:

- Two hot (>150 GHz higher temp.; > 38 GHz lower temp.);
- One at ambient temperature.



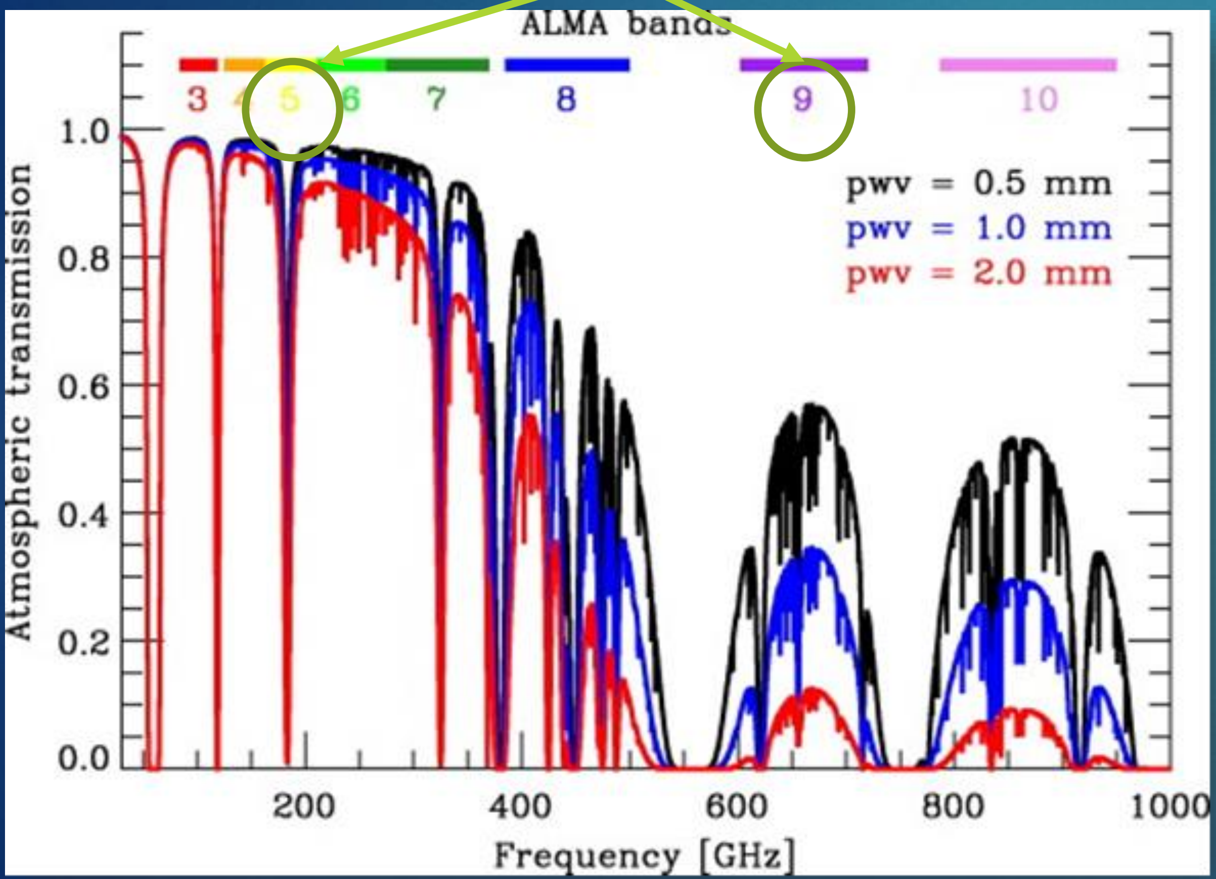
Development of electronic and software to control the temperature

Subsystem

Receivers

Collaborators:

First receivers for LLAMA



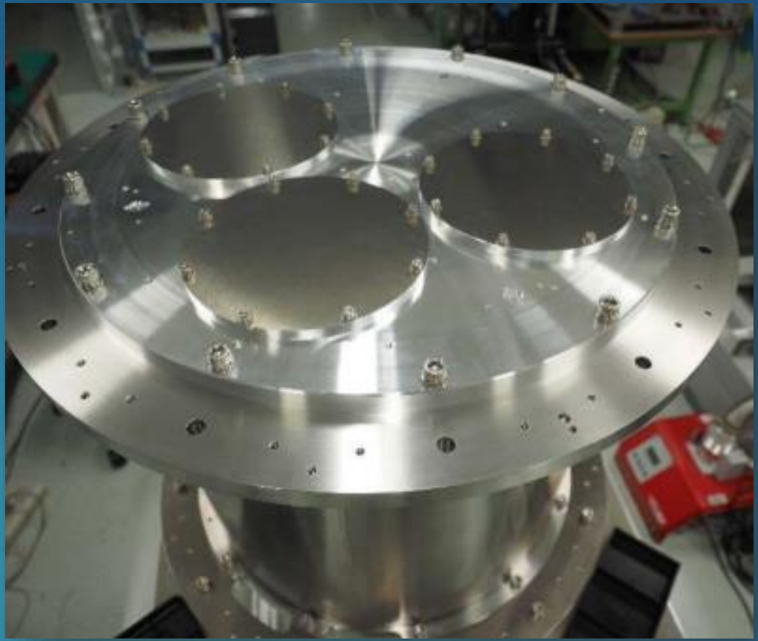
ALMA bands:

- **Band 1: 35 GHz - 52 GHz -> Atibaia**
- Band 2: 67 GHz - 90 GHz
- **Band 3: 84 GHz - 116 GHz**
- Band 4: 125 GHz - 163 GHz
- **Band 5: 163 GHz - 211 GHz**
- **Band 6: 211 GHz - 275 GHz -> for VLBI; EHT**
- Band 7: 275 GHz - 373 GHz
- Band 8: 385 GHz - 500 GHz
- **Band 9: 602 GHz - 720 GHz**
- Band 10: 787 GHz - 950 GHz

Team (not complete for sure!): Juanjo Larrarte, Danilo Zanella, Guillermo Gancio, Sandro Verri, Marcos Luqueze, Jacques Lépine.

Band 5, (OSO; NOVA)

Band 9 (NOVA)

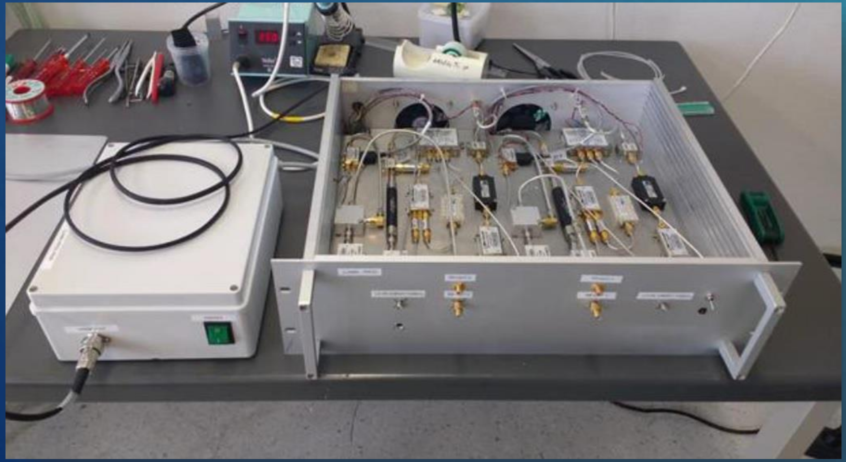


Cryostat (NAOJ; NOVA)

Front-End

Integration

Backend



IF Processor (IAR; NOVA)

Spectometer

Subsystem

Software

→ "The alma of LLAMA" -> see the contribution by Danilo Zanella.

- Team (October 2019): Guillermo G. de Castro, Cesar Strauss, Sjoerd Themba Timmer & Danilo Zanella.

- Development based on ALMA Common Software (ACS).

Examples of tasks:

- Control of antenna position, pointing and tracking;
- Reading of sensors;
- Adjustment of receiver parameters;
- Setting position of mirrors (NACOS) and calibration loads (robotic arms);
- Data acquisition;
- Archiving.

Some obstacles; possible solutions

- Main problems and delays in the LLAMA development have been caused by crisis in the Argentinean organization for the project, exacerbated by the economic and political situation of that country.

- In Brazil, the project is affected by already well know issues in scientific instrumentation:
  - Bureaucracy for procurement;
  - Few people involved and difficulty to keep them in a long-term project;
  - Lack of adequate knowledge in Project Management and System Engineering.

→ SPAnet can help organizing courses, schools and events related with management of astronomical instrumentation projects.

Perspectives

- With the new Argentinean members of the Steering Committee, it is expected a definition about the construction of the concrete base for the as soon as possible.

  → Any schedule would be realistic without the information of the date of start of the construction work.

- Brazil is already negotiating two other receptors:
  - Band 6: collaboration with BRICS and NOVA -> **VLBI** and **EHT**;
  - Band 2+3: production line for ALMA; collaboration with NOVA.

- Conversation about future instruments for Cassegrain focus is ongoing.

LLAMA is open for new partners!