

LLAMA

Large Latin American Array

FAPESP-Max Plank Institutes Meeting
Jacques Lepine November 2018



Hi guys
I will be there



Ministerio de
Ciencia, Tecnología
e Innovación Productiva
Presidencia de la Nación

The Brazilian background in Radio Astronomy



BEAST Background Emission....
launched by balloons 2000-2005

Brazilian Decimetric Array - BDA
Cachoeira Paulista



Itapetinga Radome-enclosed 13.7m dish
20-45 GHz



Galactic Emission Mapping GEM
INPE



Submillimetric (212 and 405 GHz) telescope for
solar observations - El Leoncito, Argentina

International Context

ALMA is the most important project in radioastronomy of the world (USA, Europe, Japan, Canada) -66 radiotelescopes, most with 12m diameter, operating in the range 0.1 to 1 THz approx. In Atacama desert, Chile, 5000 m altitude



APEX European radiotelescope

ALMA



LLAMA objective: installation of a 12 m radiotelescope in the Andes in Argentina at 4800 m altitude for mm/sub-mm astronomy

Agreement FAPESP-USP-Mincyt

Equal contribution from Brazil and Argentina
About 20 million dollars investment

Argentinean side: road, local buildings,
electricity generators, telecommunications

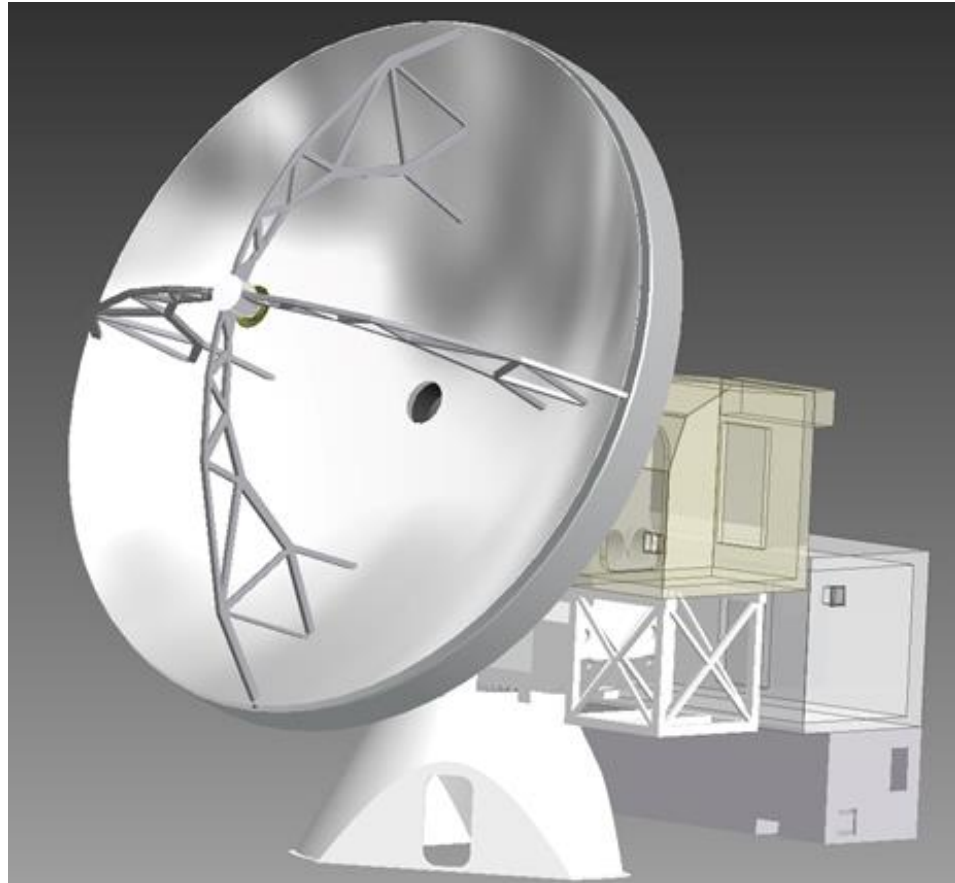
Brazilian side

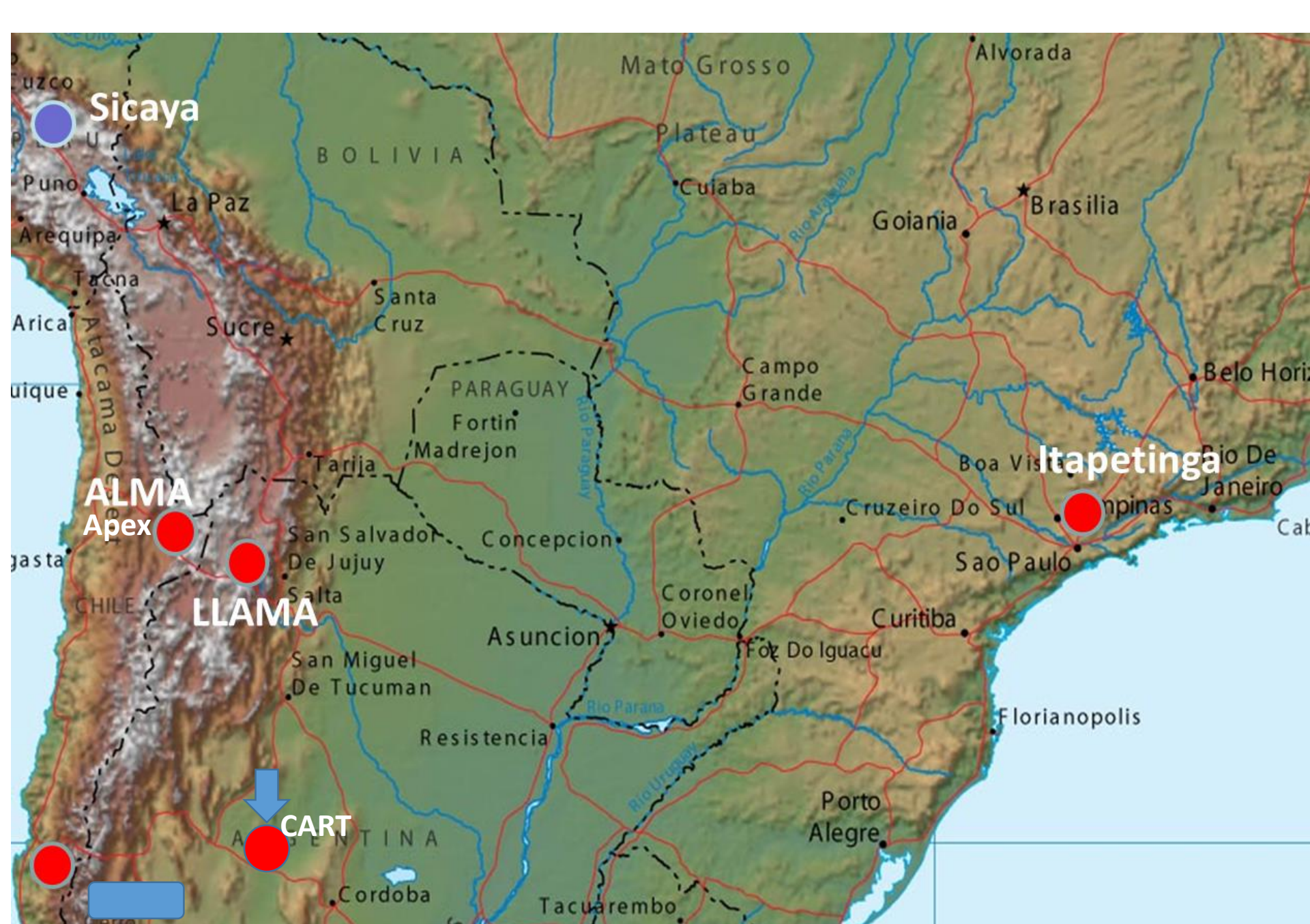
Acquisition of a VERTEX antenna

Shared activities

Cooled receivers, cryostats, back-ends,
Fast Fourier Transform Spectrometer
holographic receiver, data acquisition system,
etc Acquired by means of international
collaborations, using reserve funds from
FAPESP, and Argentinean funds

Collaboration from NRAO, NAOJ (Japan),
GARD (Sweden). Important help from NOVA
(Groningen) for the receivers





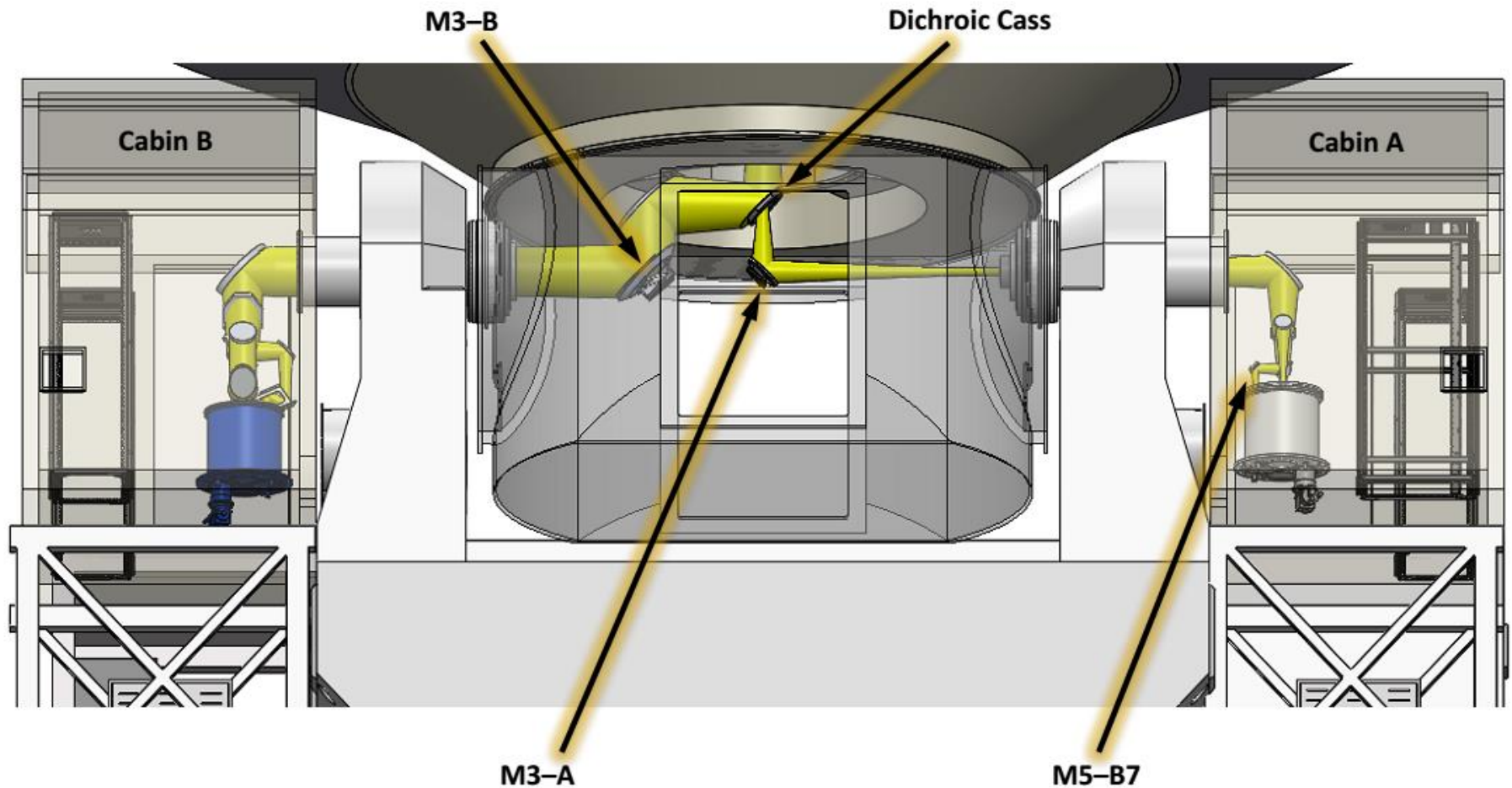


LLAMA today: antenna arrived at the site, waiting for mounting

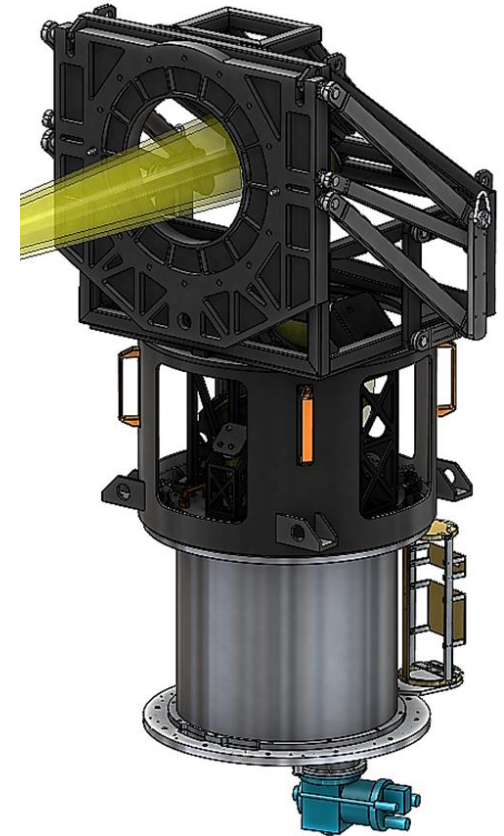
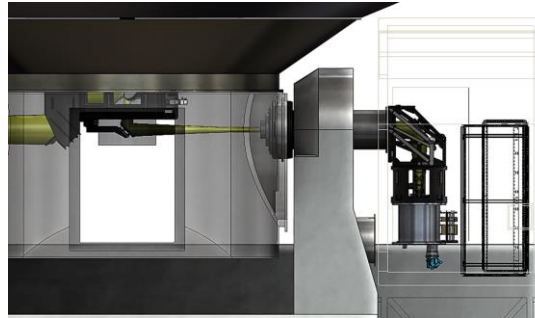
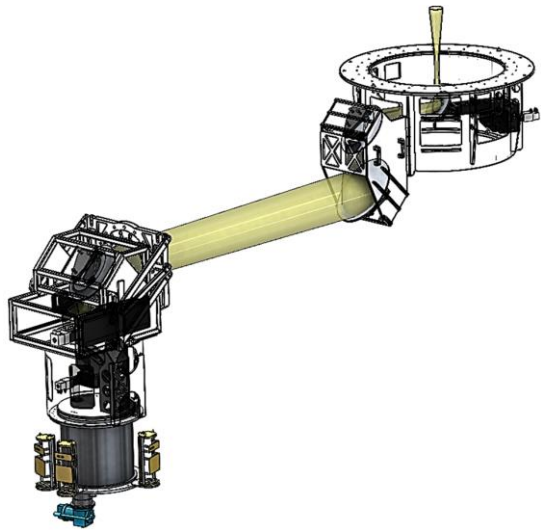
Building of the headquarters in San Antonio de los Cobres



Antena has space for the development of equipment



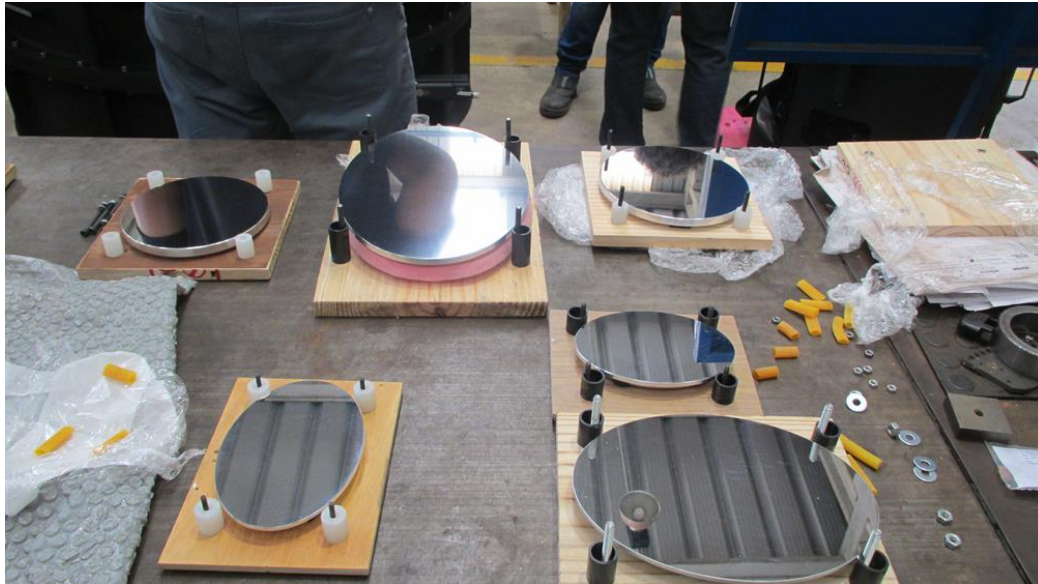
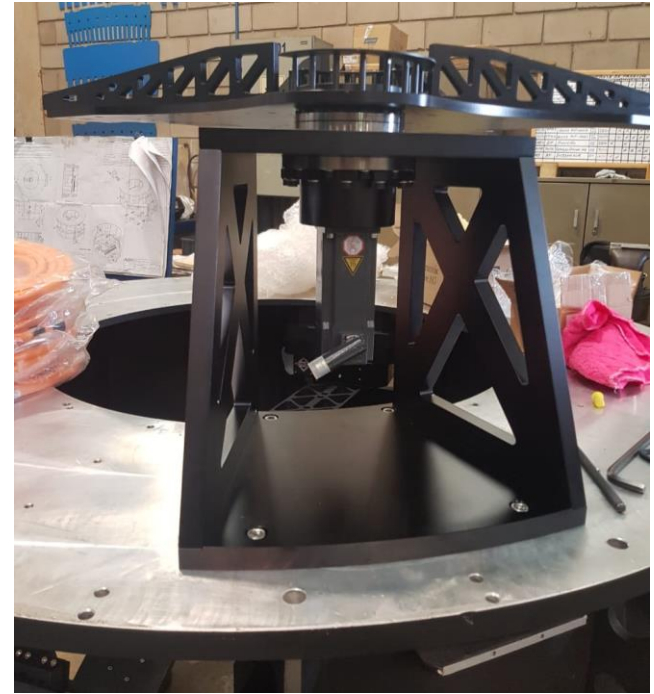
Optical path, mirrors, criostats

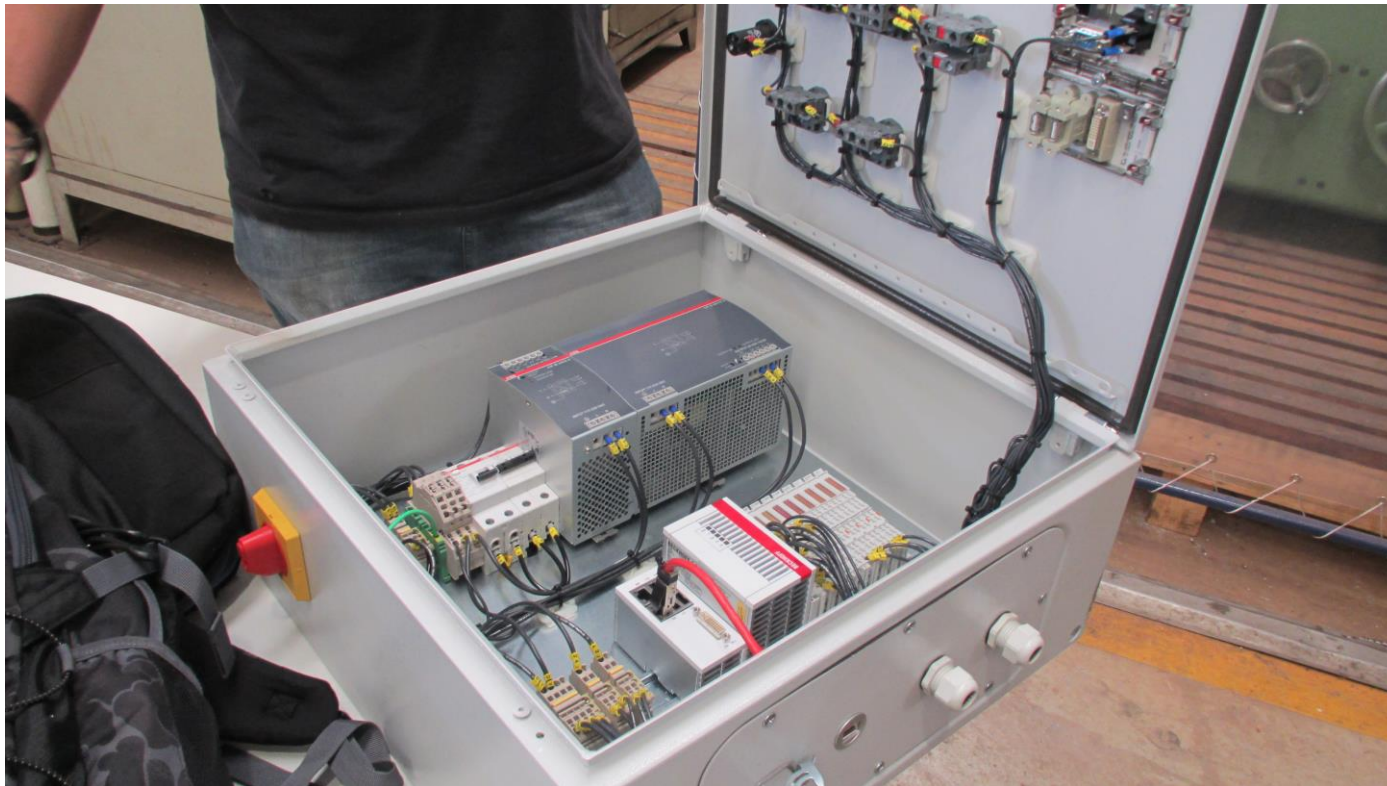


Concept of Nasmyth cabin Optical System

We will start with a descoped Project, only one Nasmyth cabin will be populated (1 cryostat, 2 receivers)

NACOS, including all the mirrors, and calibration loads mechanical system, in Araraquara





Control system for motors in Nasmyth cabin

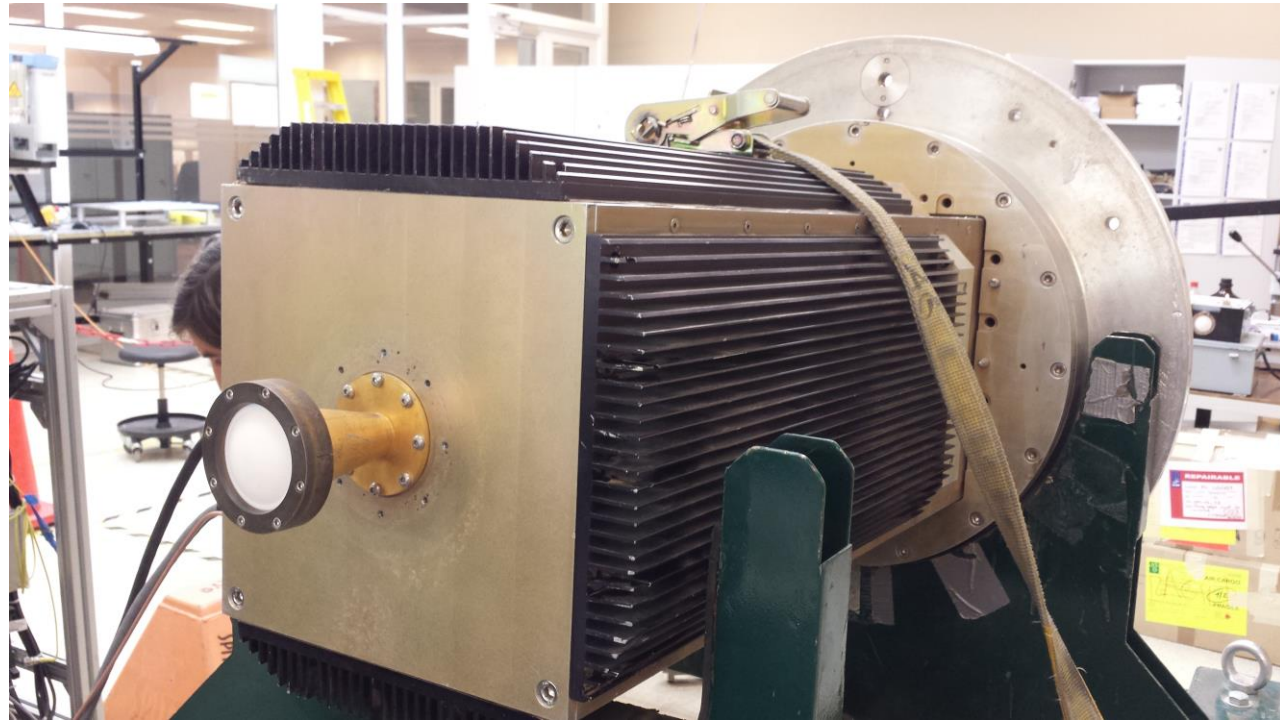


Equipment needed before first light:

- Optical telescope + câmera, for pointing
- Holographic transmitter and receiver, for the adjustment of panels of the dish



Holographic receiver
will be on loan from
NRAO

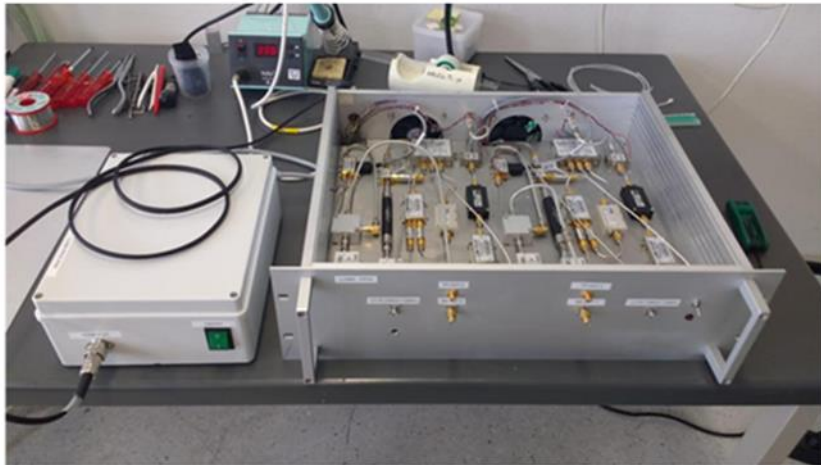


Fast Fourier Transform Spectrometer (RPG)

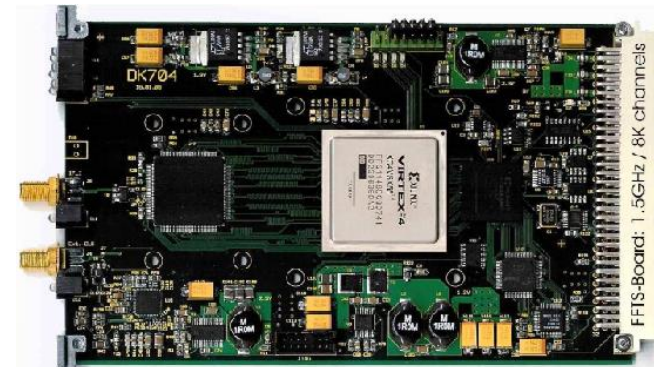


19" crate with 8 FFTS boards and 1 controller

Prototype IF processor mounted at NOVA



- **Signal Input: DC - 1.5 GHz**
- **ADC: 8 bit**
- **DSPL Polyphase filter bank (FFT)**
- **Resolution: 212 KHz @1.5 GHz BW**
- **Channel spacing 183 KHz**
- **Spectral Channels: 8192 (8K) @1.5 GHz BW**

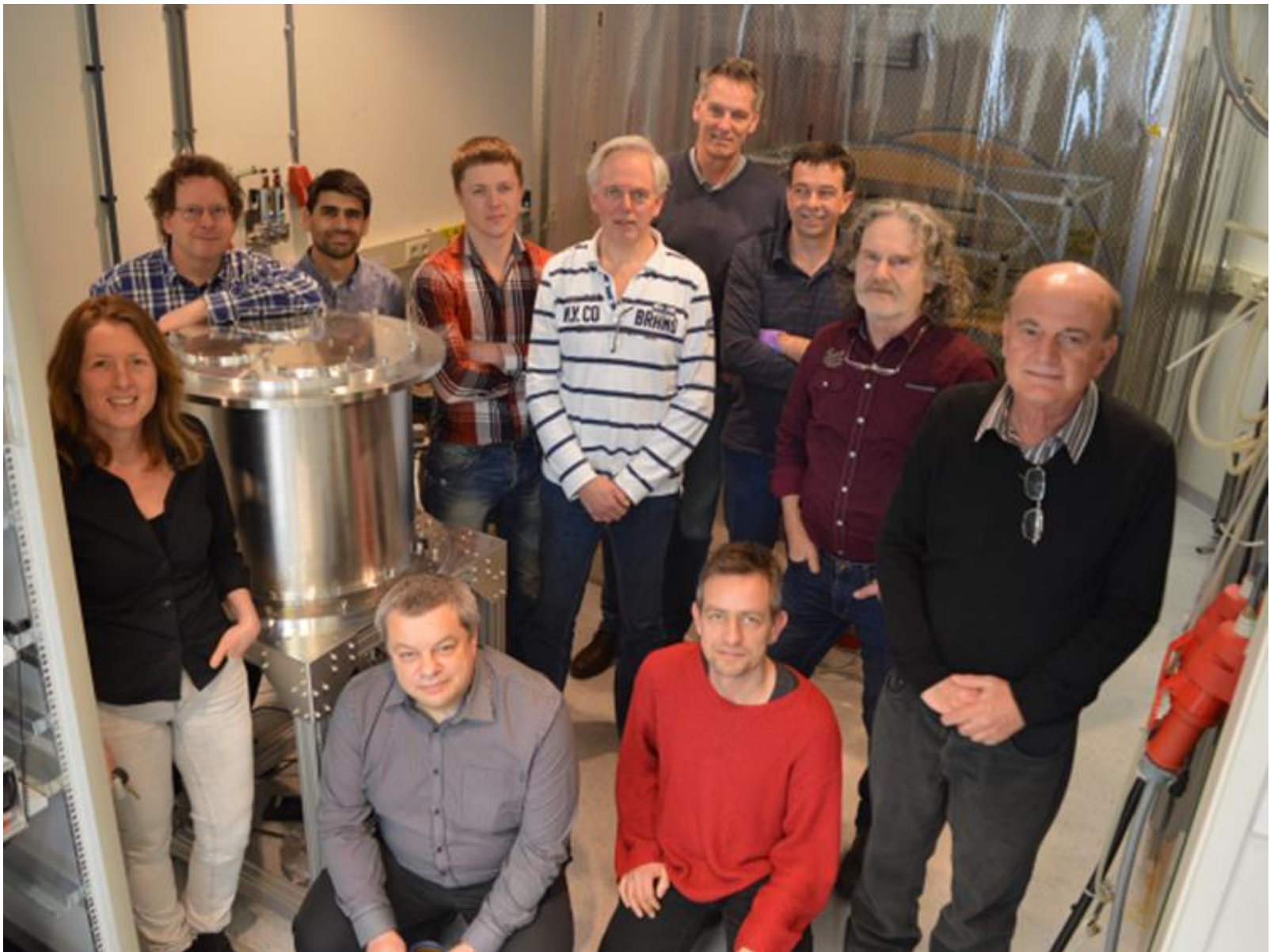


Software team at work

At IAG- São Paulo, May 2016,
With participation of 3 Chileans

At VERTEX (Duisburg,
Germany, testing
Commands of antenna
May 25, 2016





**Team working with cryostat and reveivers, there is 1 Argentinean and 2 Brazilians
At NOVA, Groningen**

Scientific perspectives

- **VLBI images** of regions a few times the horizon size of super-massive black holes (e.g. Sgr A*, Cen A, etc.).

Event Horizon Telescope Several mm radiotelescopes with
Thousand km separations to observe the Black Hole of
our Galaxy

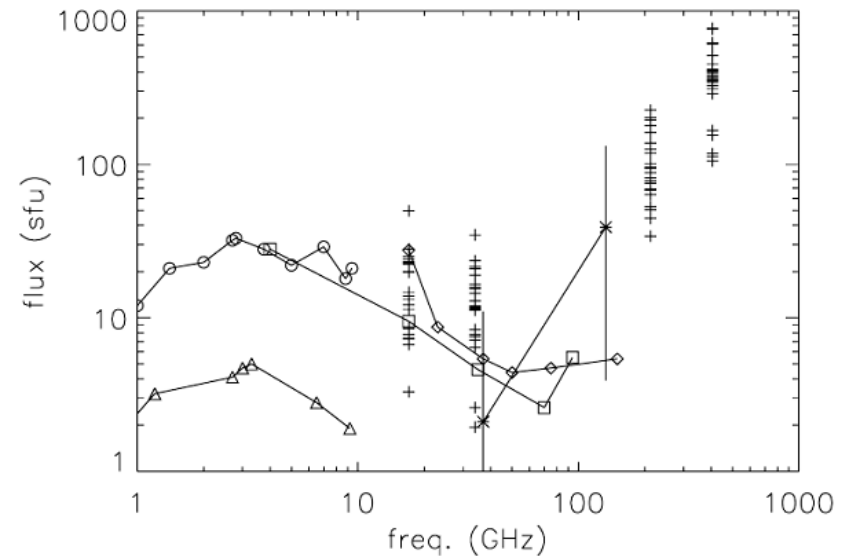
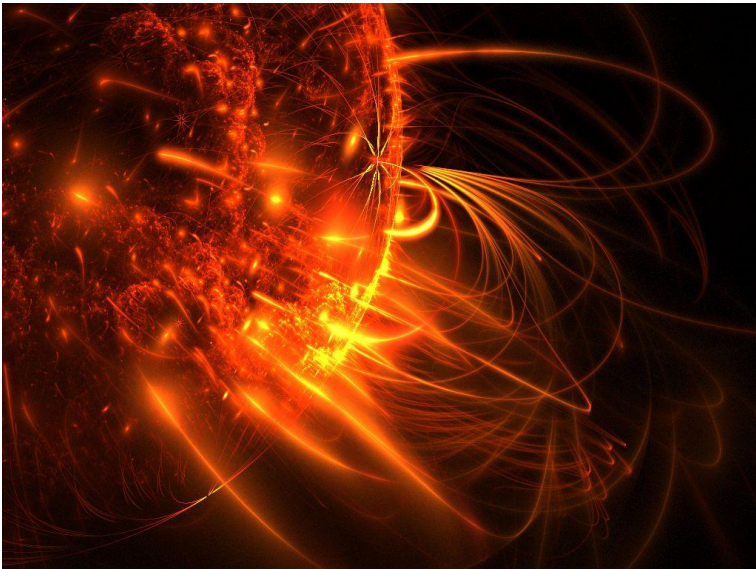
- Galaxy Formation in the Early Universe
- Extragalactic megamasers of water molecules
- Masers of recombination lines of the hydrogen atom.
- Star-formation regions
- Planetary Nebulae and AGB Stars
- **Astrochemistry: molecular evolution of interstellar clouds**
- Spiral structure of the Galaxy and other galaxies
- Molecular absorption in front of quasars at very high Z s
- Extra-solar planets and proto-planetary disks
- Polarimetry of radio sources and of the Interstellar Medium
- **Solar Physics**

Time schedule

- Construction of concrete base 2019 feb- June
- Mounting antenna 2019 Aug – 2019 Nov
- Pointing measurements 2019 Dec-2020 Jan
- Holography 2020 Jan- 2020 Feb

Solar Physics

- LLAMA can extend the frequency coverage up to 1000 GHz with the addition of polarization information. Joint observations with SST (mostly 212 GHz), and the other patrol telescopes from 1 to 90 GHz will complete a spectrum with almost three orders in frequency
- **Simultaneous observations at different frequencies** will be a plus of LLAMA for the observation of flares. We will be able to measure the delay between the maximum of a flare between frequencies, which is due to the propagation of radiation in the plasma



Comparison of submillimeter active region
Flux density spectra with previously
published data. From Silva et al. (2005)

Membros da equipe brasileira

- **Jacques Lépine** coordenador IAG-USP
- **Zulema Abraham** vice-coordenadora IAG-USP
- **Carlos Guillermo Giménez de Castro** Dr., Astronomia, membro CE, Universidade Mackenzie
- **Joaquim Eduardo Rezende Costa** Dr., Astronomia, membro CE, Inpe/MCT
- **Fatima Salete Correra** Dr., Engenharia Escola Politécnica -USP
- **Tânia Pereira Dominici** Dr.,Astronomia MAST/MCT
- **Antonio Sandro Verri** Dr.,Engenharia Escola Politécnica- USP
- **César Strauss** Dr., Engenharia Inpe/MCT
- **Danilo Zanella** MSc., Física, IAG/USP
- **Marcos Aurelio Luqueze** MSc. , Engenharia Escola Politécnica, USP
- **Sjoerd Themba Timmer** Dr., Computação, Radboud University Nijmegen

Colaboradores principais

- **Thijs de** Mentor, ALMA project
- **Juan José Larrate** Project Manager IAR.Argentina
- **Juan Pablo Garcia** Project engineer (IAR) Initial planning of electronics
- **Jacob Kooi** Optical design and much more Caltech
- **Fernando Santoro** Mechanical design of NACOS (Astro-EME) USA
- **Carlos Fermino** Mechanical manufacturing of NACOS
- **Emiliano Rasztoky** Design, layout and installation of instruments (IAR)
- **Rodrigo Reeves** Project of Calibration Loads