LLAMA AND INTERNATIONAL COLLABORATION

Tens of first line scientists around the world are working for LLAMA, or discussing plans for LLAMA. Our projetct already gained enormous visibility

Jacques Lepine – IAG-USP-

- La Plata, March 28, 2016

Thijs de Graauw (mentor)

Institutions

ALMA

Chile

Universidad de Chile
Universidad de Concepción
Universidad de La Frontera

Netherlands

NOVA Groningen

Sweden

Chalmers University Gothenburg

France and Germany

IRAM Grenoble (post-doc)

FRANCE

IPAG Grenoble (post-doc)
IAP Paris (QUBICS)
LAM Marseille (CONCERTO)

USA

NRAO

Japan

NAOJ

Technical advisers

Jacob Kooi (Caltech, JPL)
Juan Pablo Garcia
Jorge Ibsen (ALMA)
Jacob Baars

Science External Adviser Committee

Catherine Cesarsky (France)
Lars-Ake Nyman (ALMA)
Riccardo Giovannelli (Cornell)

In less than 2 years we reached this situation

competitiveness

Radiotelescopes above 4000 m

ALMA 66 x 12m antennas		Chajnantor	5000 m	Chile	USA, ESO, Japan/Taiwan
APEX	12m	Chajnantor	5000 m	Chile	Sweden, Germany, ESO
ASTE	10 m	Pampa la Bola	4800 m	Chile	Japan
JMCT + SMA + 8 x 6m	15 m	Mauna Kea	4100 m	USA	East Asian Observatory
LLAMA	12m	Chorillos	4800 m	Argentina	Argentina+ Brazil
LMT	50 m	Sierra Nevada	4600 m	Mexico	Mexico, USA
NANTEN 2	4m	Chajnantor	4865 m	Chile	Japan, Korea

The only single dish able to observe the Sun

ALMA is the most important project in astronomy of recent years

66 radiotelescopes 12m diameter, frequency range 100 GHz to 800 GHz, in North of Chile, 5000 m altitude
Collaboration of US, Europe, Japan

Thijs de Graauw was the director of ALMA during the last 5 years before dedication

Now Thijs plays an essential role of superadviser or mentor of LLAMA

Collaboration with Universidad de Chile

The strong support from Leonardo Bronfman and Ricardo Finger let it clear that LLAMA will be a Latin American Projectm, not only Argentinean-Brazilian Chile has the expertise to build receivers.

Several of our meetings were made at Cerro Calán

Ricardo Finger

Ricardo is oficial member of the LLAMA Instrumentation Group, participated in a large number of meetings of the of this Group. His knowledge has been very valuable

-prepared a plan for the construction of a band 1 receiver (31-45 GHz) and

-of a band 3 receiver (84-116 GHz (possibly extending the frequency range to cover band 2 -67-90 GHz), with inovative technology MMICs

- Universidad de Concepción

Rodrigo Reeves is strongly collaborating with the Instrumentation group

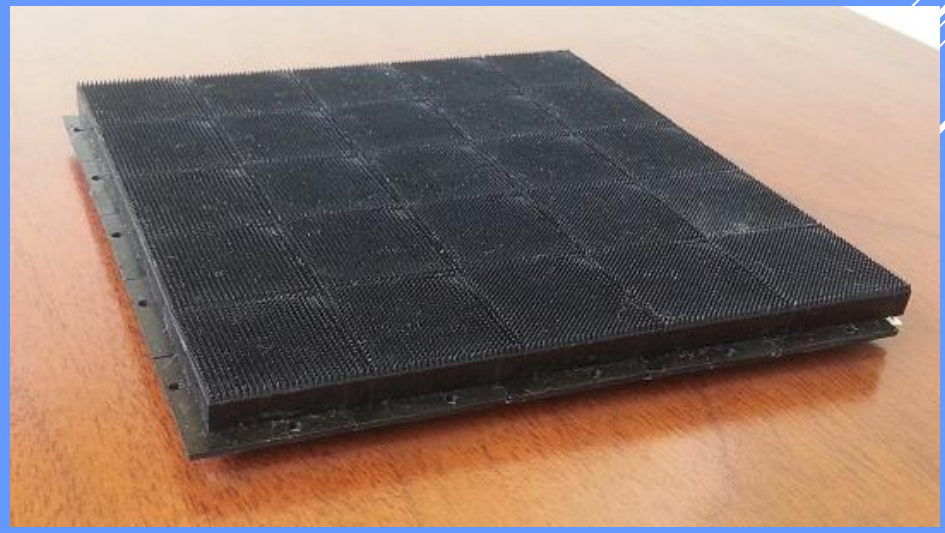
-design of a sustem of calibration loads for LLAMA

- Presented a proposal to construct a Water Vapor Receiver to monitor the water vapor content of the atmosphere

- Juan Pablo Garcia is now working as na adviser electronics, receivers, organization of space and equipment in the cabins

- Universidad de La Frontera

A collaboration started recently. Sudents, interns of the Computation Course of UFRO are working on the control software of LLAMA antena, in collaboration with ALMA

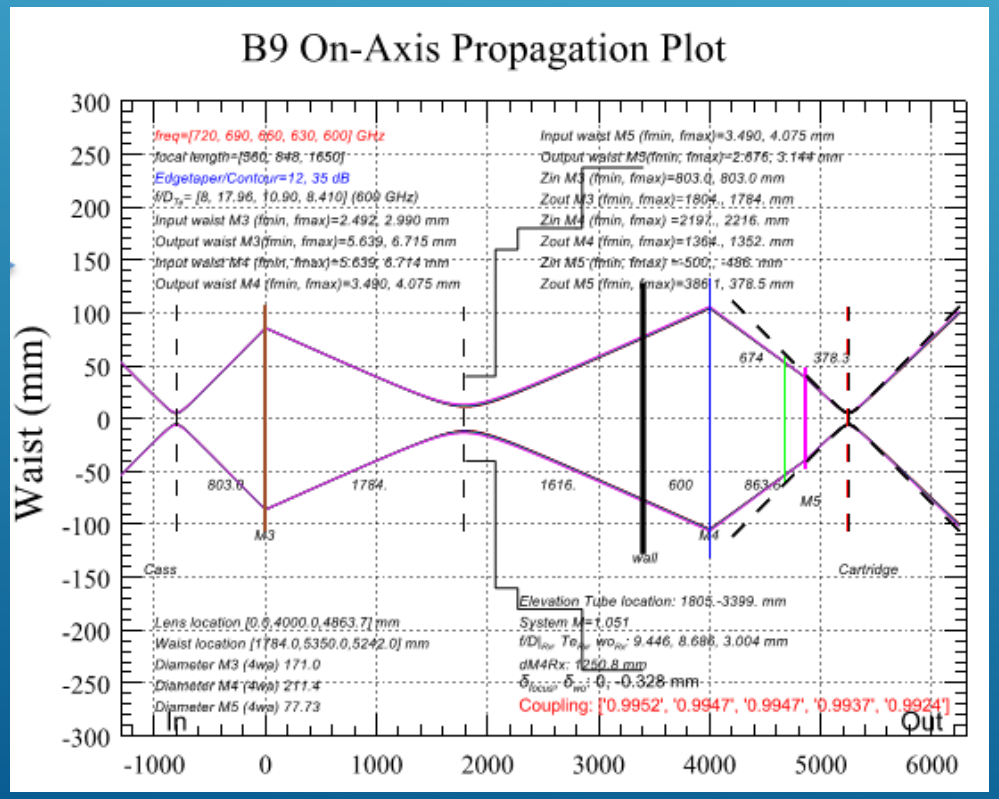


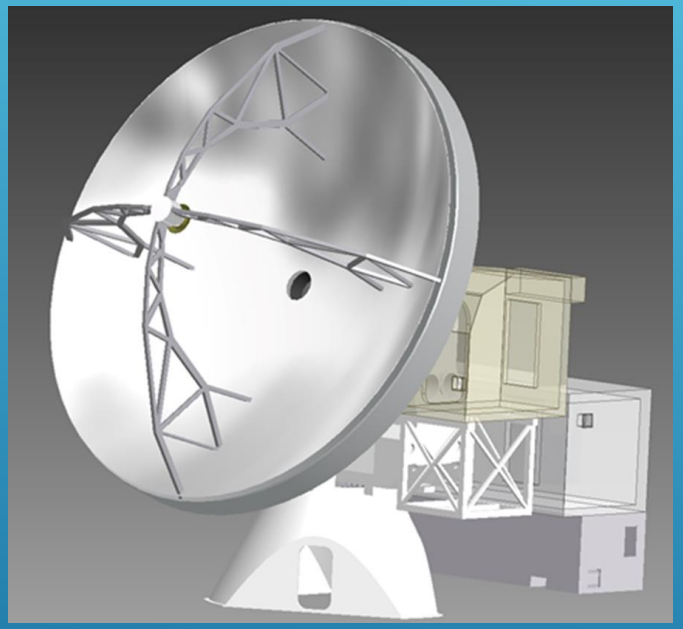
Test load assembled
at UdeC with small TK tiles

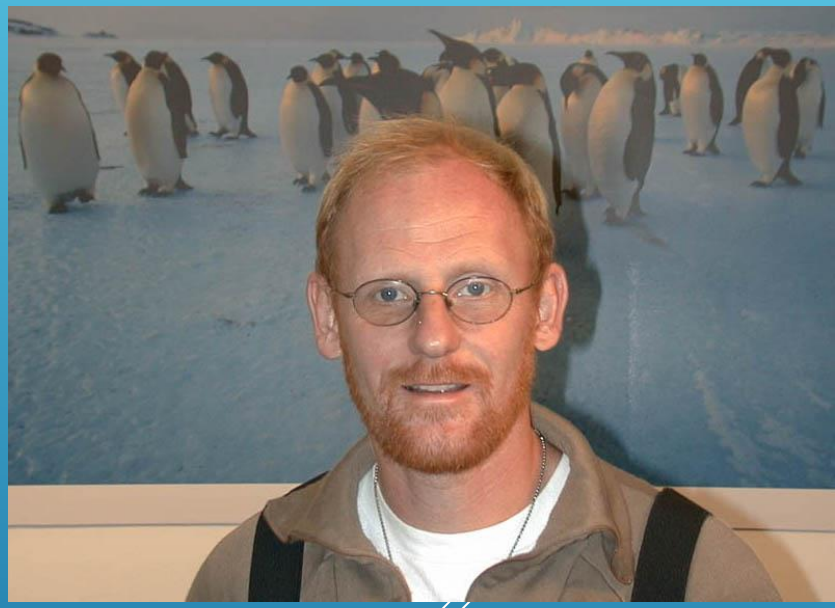
Jacob Kooi (Caltech and JPL) is much more than an adviser. He is deeply committed with LLAMA since the begining,

Constructed a 3D model of the antena whichaloowed to Discuss the space organization

Calculated the optics needed to transport the radiation To tehe entrance of the receivers





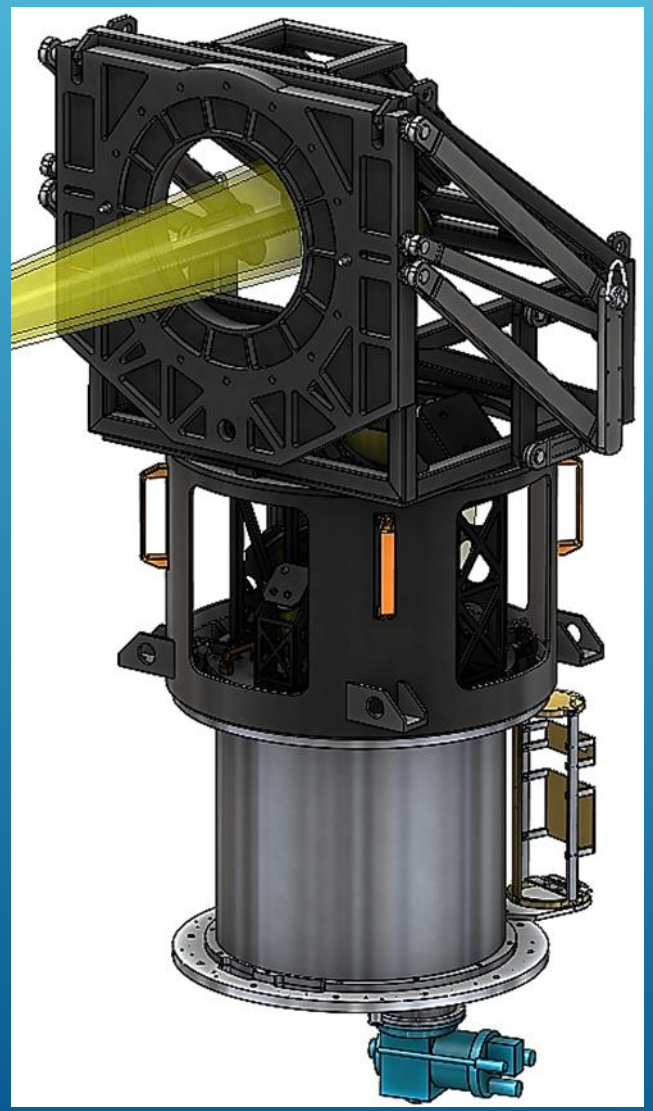


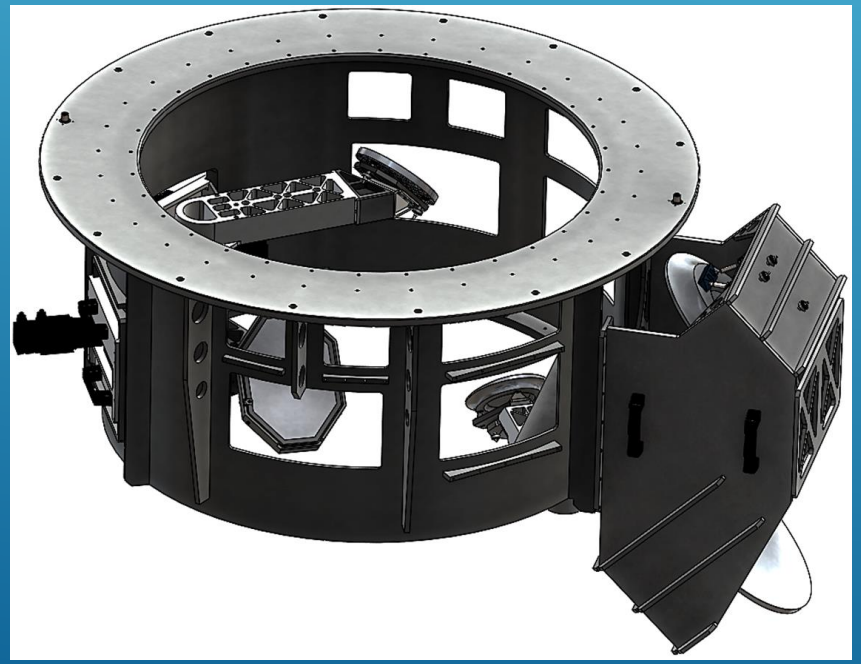
IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY 1

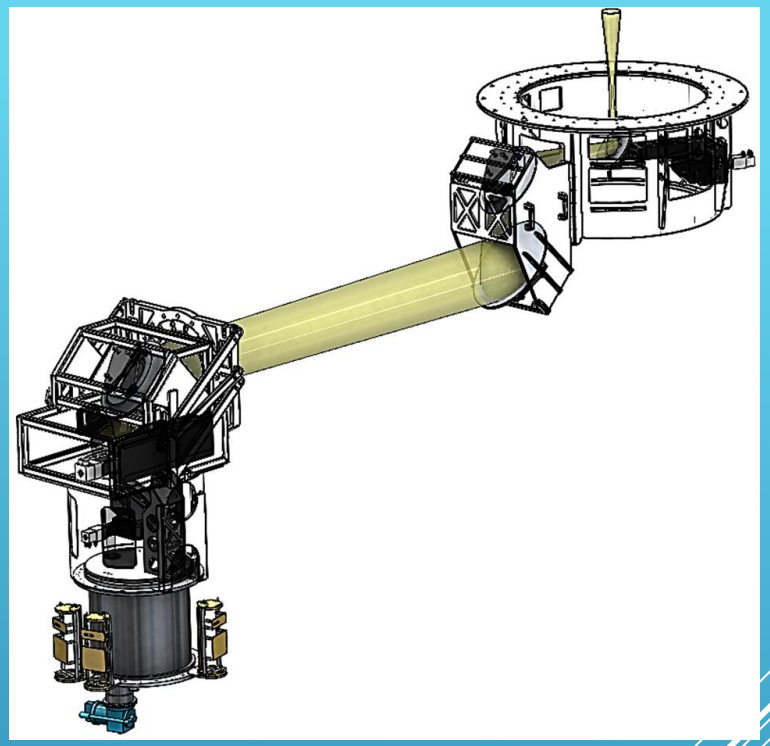
Balanced Receiver Technology Development for the Caltech Submillimeter Observatory

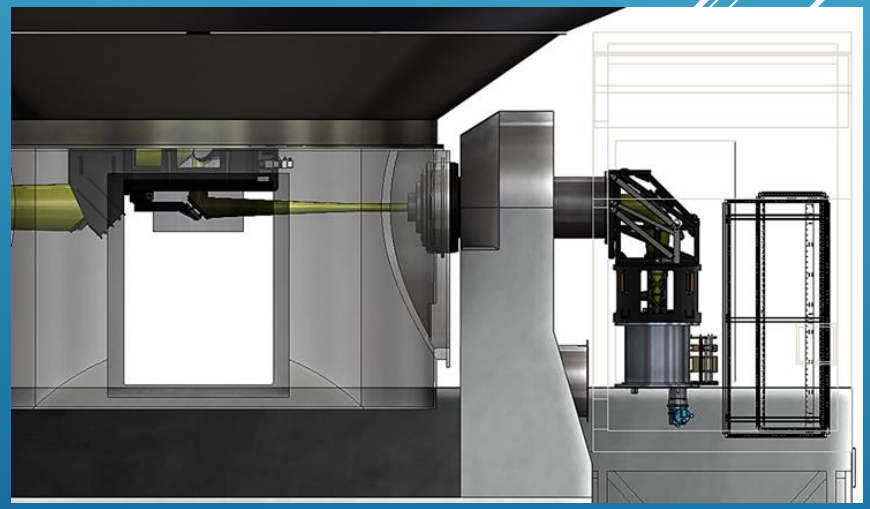
Jacob W. Kooi, Richard A. Chamberlin, Raquel Monje, Brian Force, David Miller, and Tom G. Phillips

Fernando Santoro ASTRO Electro-Mechanical Engineering LLC
USA - is designing the mechanical parts and set of mirrors
Based on the optical design of Jacob Kooi









NOVA

THE NETHERLANDS RESEARCH SCHOOL FOR ASTRONOMY
(Nederlandse Onderzoekschool Voor Astronomie)
A collaboration between the Universities of Amsterdam, Groningen, Leiden and Nijmegen

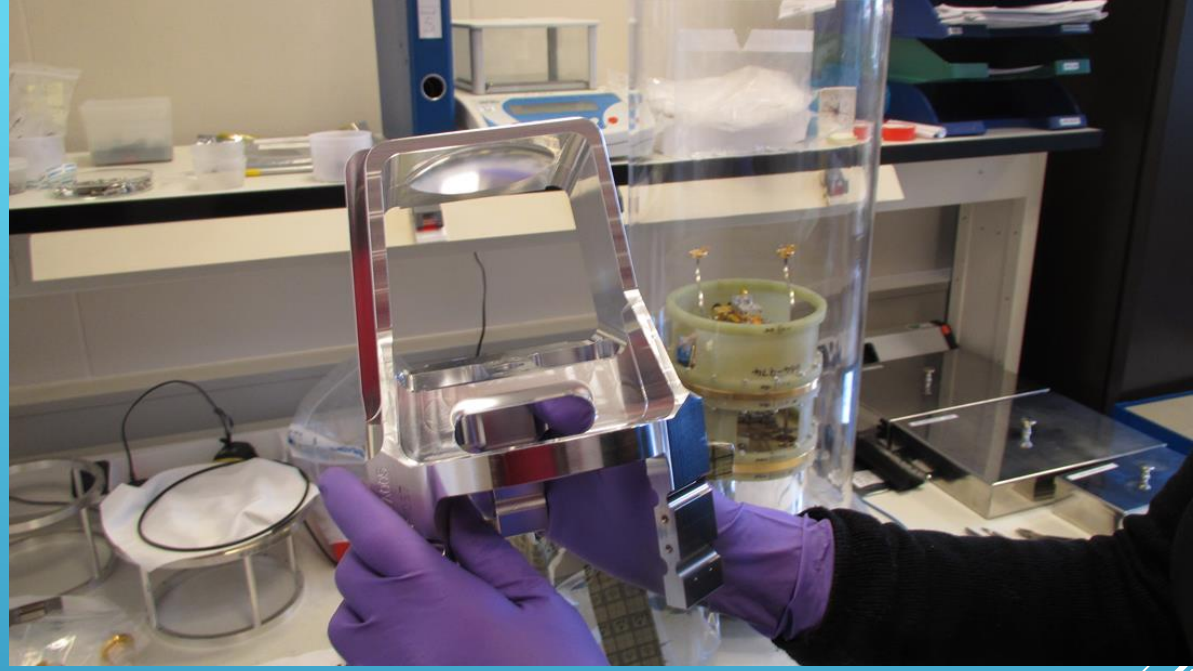
Wilfried Boland, Andrey Baryshev, Jan Barkhof, Andrey Khudchenko

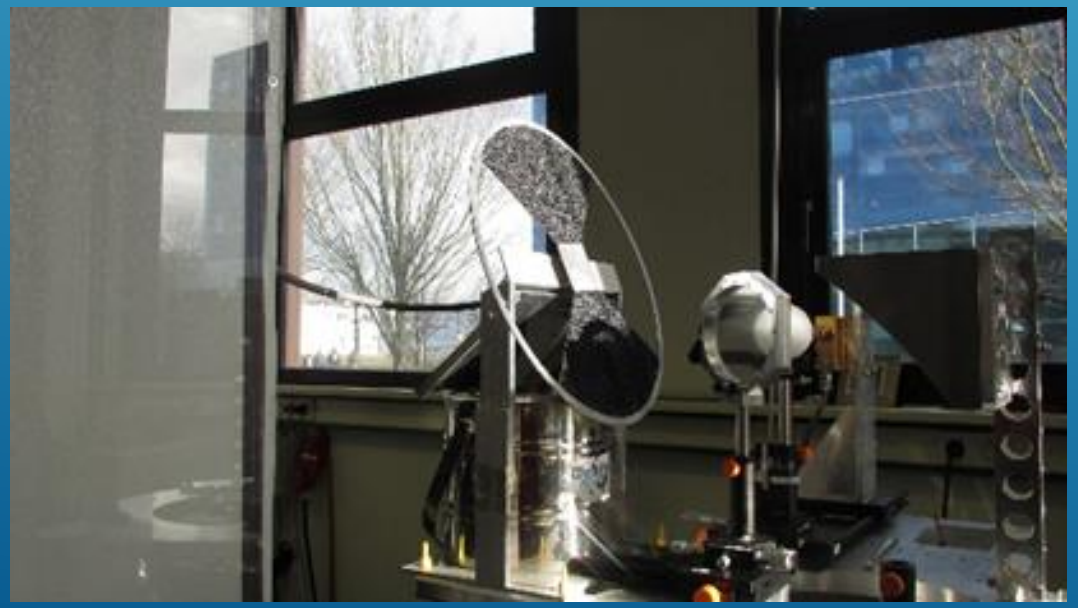
- NOVA was responsible for the construction of the 66 Band 9 receivers for ALMA
- Nova offered us a Band 9 receiver for LLAMA
- NOVA offered to integrate and test not only the band 9, but also the band 5 receiver in the cryostat that we are going to use
- Working on a side-band separating 'band 9' receiver for LLAMA
- Funds have been allocated by NWO and FAPESP for this collaboration, which includes training of engineers, visits of scientists, and more

- Nova has a top level Terahertz Lab, with active research. The agreement which has been established between LLAMA and NOVA starts a long term collaboration

Right: the input optics of band 9, complex but made in a single piece.

Below: a simple calibration load system with a chopper





The Onsala Space Observatory (OSO) is run by Chalmers University at Gothenburg.
Onsala Space Observatory, the Swedish National Facility for Radio Astronomy, " provides scientists with equipment to study the Earth and the rest of the Universe".
Ricardo Finger got his PhD at this lab!

Director: John Conway

Victor Belitsky is head of the Group for Advanced Receiver Development

OSO has designed and built six heterodyne receiver cartridges for the ALMA Band 5 (covering the range 163 – 211 GHz). Pre-Production series

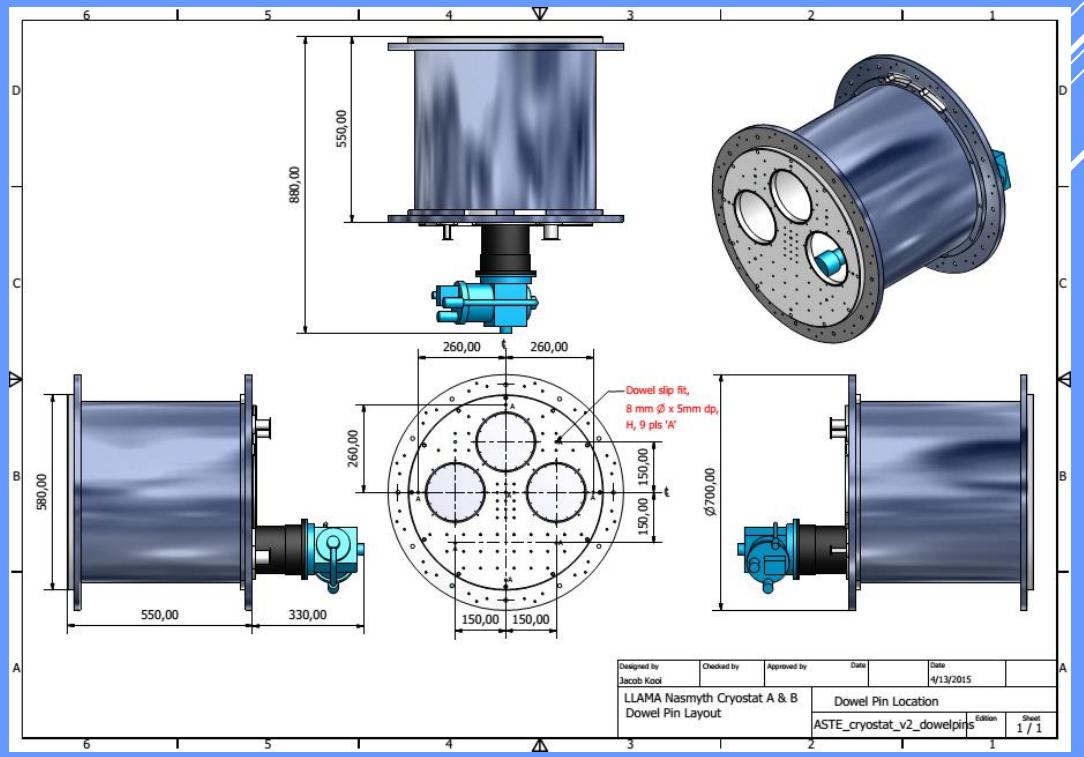
The OSO group has agreed to give us one of the pre-production receivers

This will be integrated in the cryostat together With the band 9 receiver
At NOVA - Groningen

Snow around the Onsala 20 telescope

- Working with NAOJ- The National Observatory of Japan
  - NAOJ is going to construct our first cryostat with room for 3 cartrige receivers Dr. Asayama is a true partner, having participated many times of our instrumentation meetings

We visited NAOJ and started the agreement Discussing with the Director Dr Hasegawa



NRAO National Radio Astronomical Observatory - USA

Is building for us the WCAs (Warm Cartridge Assembly) the part of the receiver that stay outside
The criostats- local oscillators and associated electronics of 2 receivers

Kamaljeet Saini

Phil Jewel, National Radio Astronomy Observatory Director

Projects for Future

QUBIC could be installed as an independent instrument within the area site of LLAMA

– 1st step: First QUBIC module (150/220 GHz – Ready in 2017)

Scientific objective: observation of the CMB (Cosmic Microwave background)

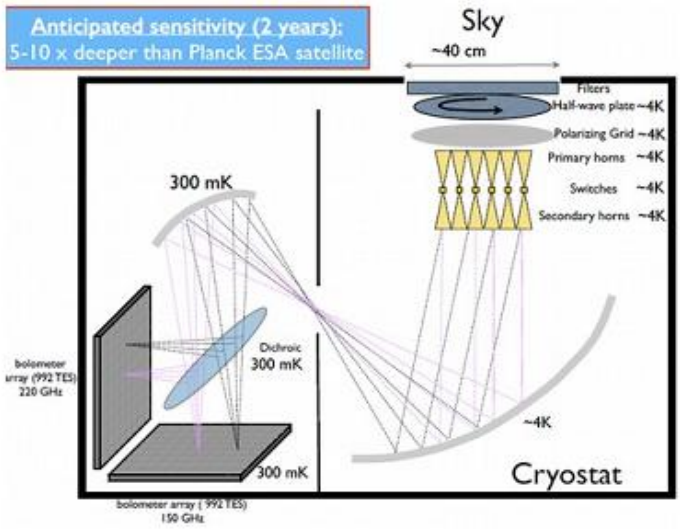
A prediction of the inflation theory of the Universe just after Big-bang is that in addition to density fluctuations, the primordial gravitational waves would have produced fluctuations in the magnetic field

QUBIC intends to investigate polarization fluctuations in the CMB of the order of nano-K

QUBIC will be installed nearby LLAMA, but is na independent Instrument, so that there is no interference with LLAMA observations

- Leader François Bouchet
- Not yet funded, very preliminary

Fig. 1. Esquema del sistema de detección combinado (interferómetro-bolométrico).



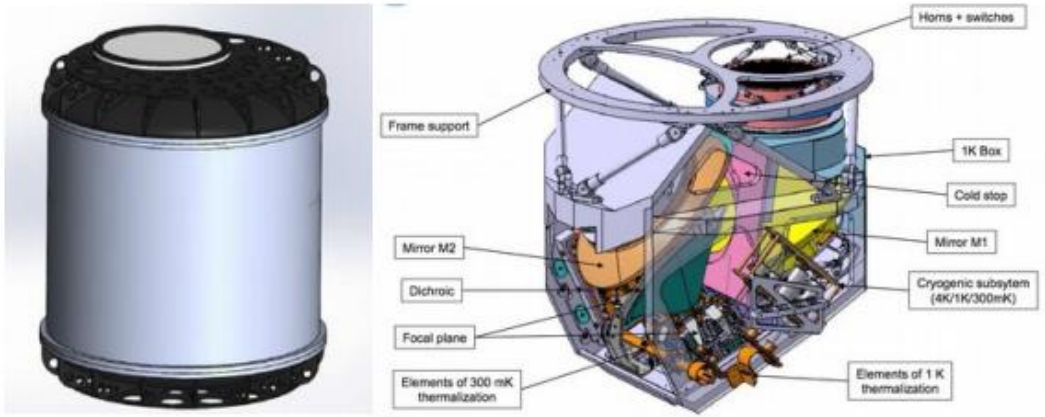
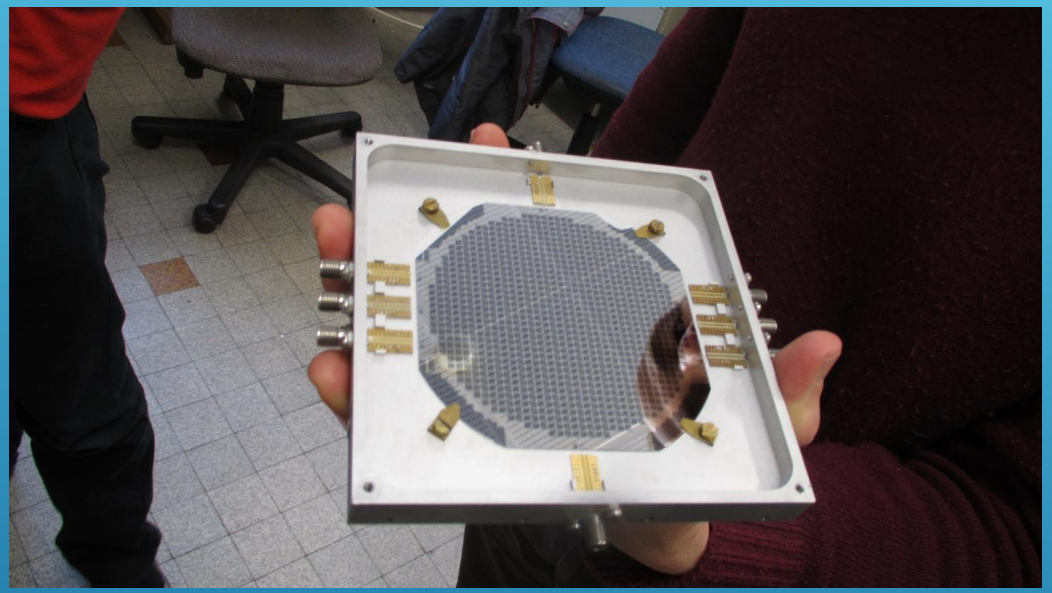


Fig. 2 Vista de la parte externa del crióstato (izquierda) y de los componentes principales del sistema completo (derecha).

CONCERTO - A proposal of an array of Kinetic Inductance Detectors (KID) by a French team leaded by Guilaine Lagache (LAM, Marseille)



Scientific Motivation

Reionization, which marks the end of the so-called "Dark Ages", was a landmark in cosmic history. It is the last unexplored phase of cosmic evolution.

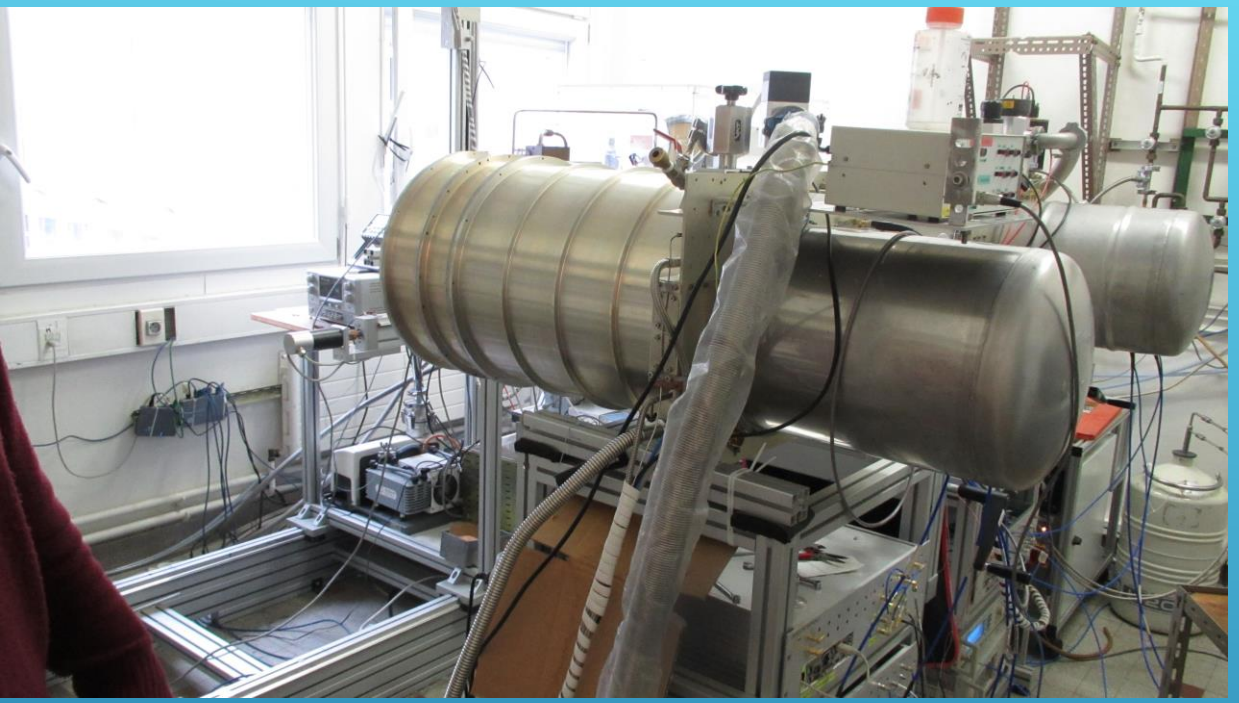
measurements of the redshifted [CII] line during the final stages of the epoch of reionization($4.5<z<8$).

Precision epoch of reionization studies with CMB experiments

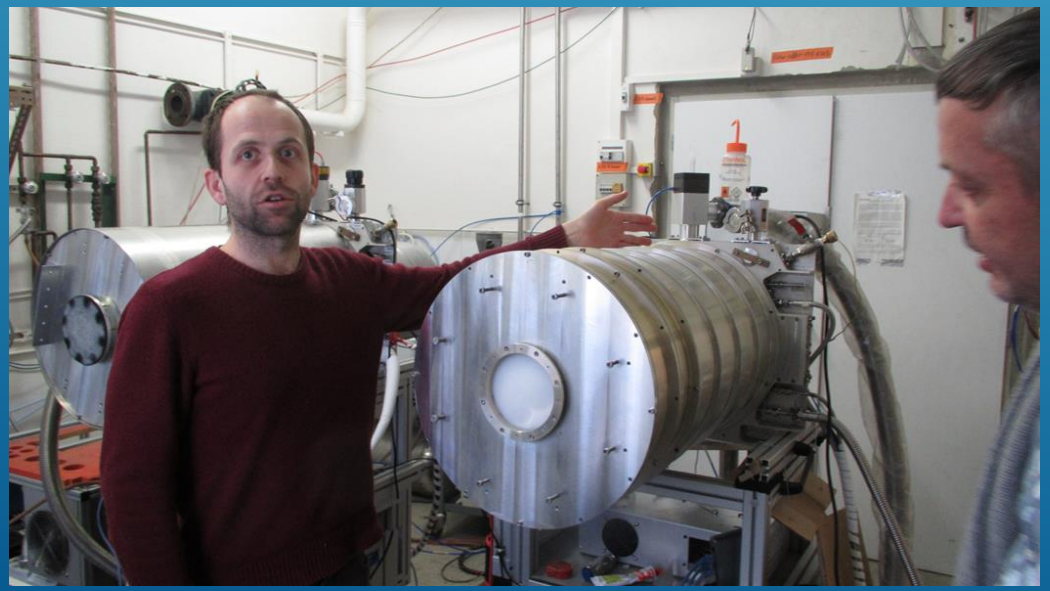
- Main characteristics
- FTS + KIDS (Fourier transform Martin-Puplett interferometer
- Spectral resolution 1.5 GHz
- Frequency covered from 200 to 360 GHz
- KIDs arrays of 1800 pixels
- FOV 12 arcmin (field of view)

- The team leading the instrument development is internationally recognized following its accomplishment in the Archeops, Planck and NIKA (New IRAM KID Arrays) instruments.

- For non-cosmologists plenty of applications. Mapping of wide areas of the sky, looking for broad lines or dust features, dense cores in molecular clouds, obscured compact HII regions, etc

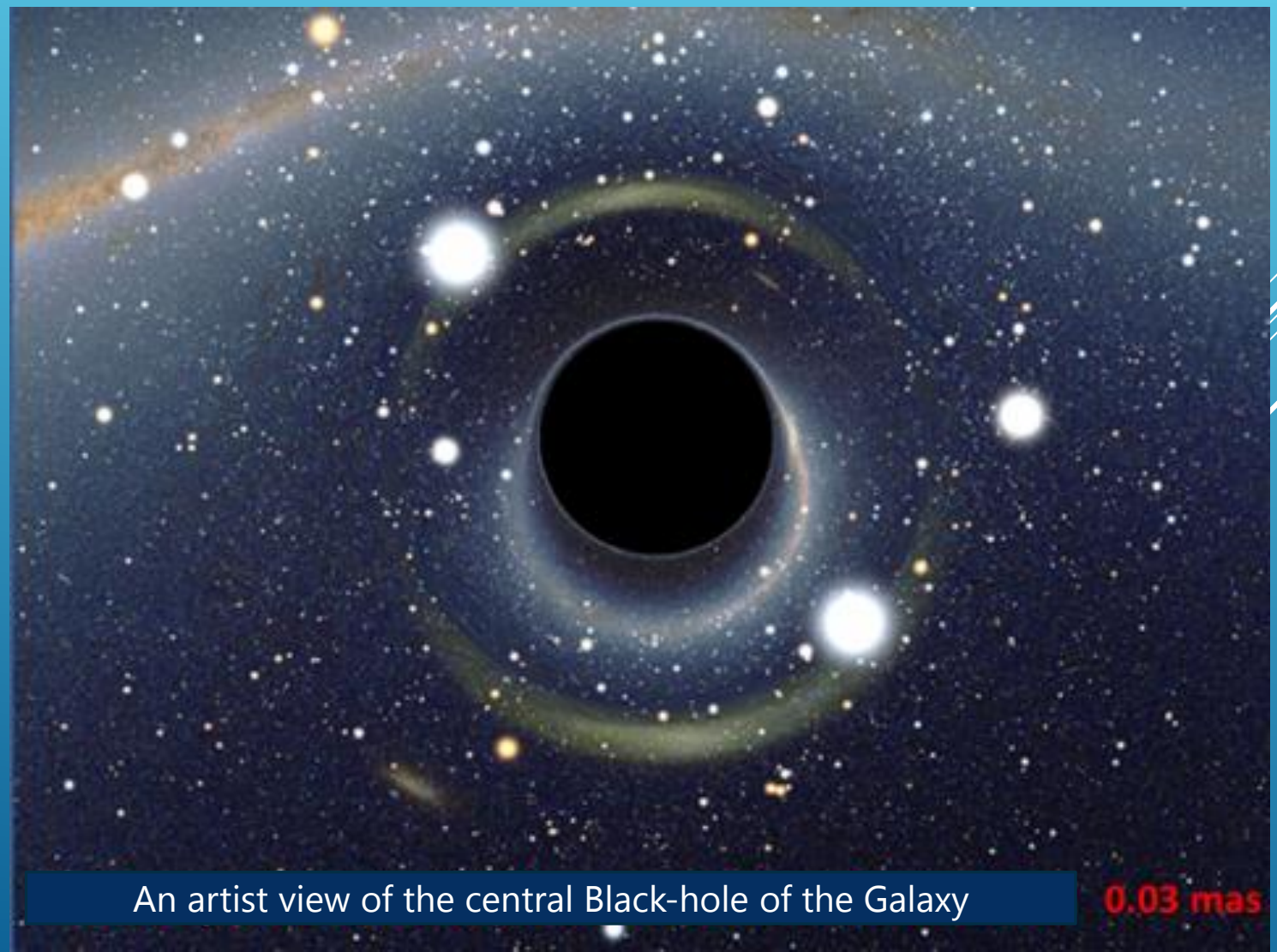


François-Xavier Désert, Alessandro Monfardini, Bertrand Lefloch at Institut Néel, Grenoble



The **Event Horizon Telescope** (EHT) is a project to create a large telescope array consisting of a global network of radio telescopes (many radiotelescopes observing simultaneously in the VLBI mode)
LLAMA will be part of this network if we succeed to be ready in time. This requires to have a band 6 receiver available, and to purchase the VLBI equipment

About 10 radiotelescopes will be available
This is the largest apparent event horizon size of any BH candidate in the Universe



: We must work fast, if we do not want to be loosers