



U. de Chile Mm-Wave Laboratory

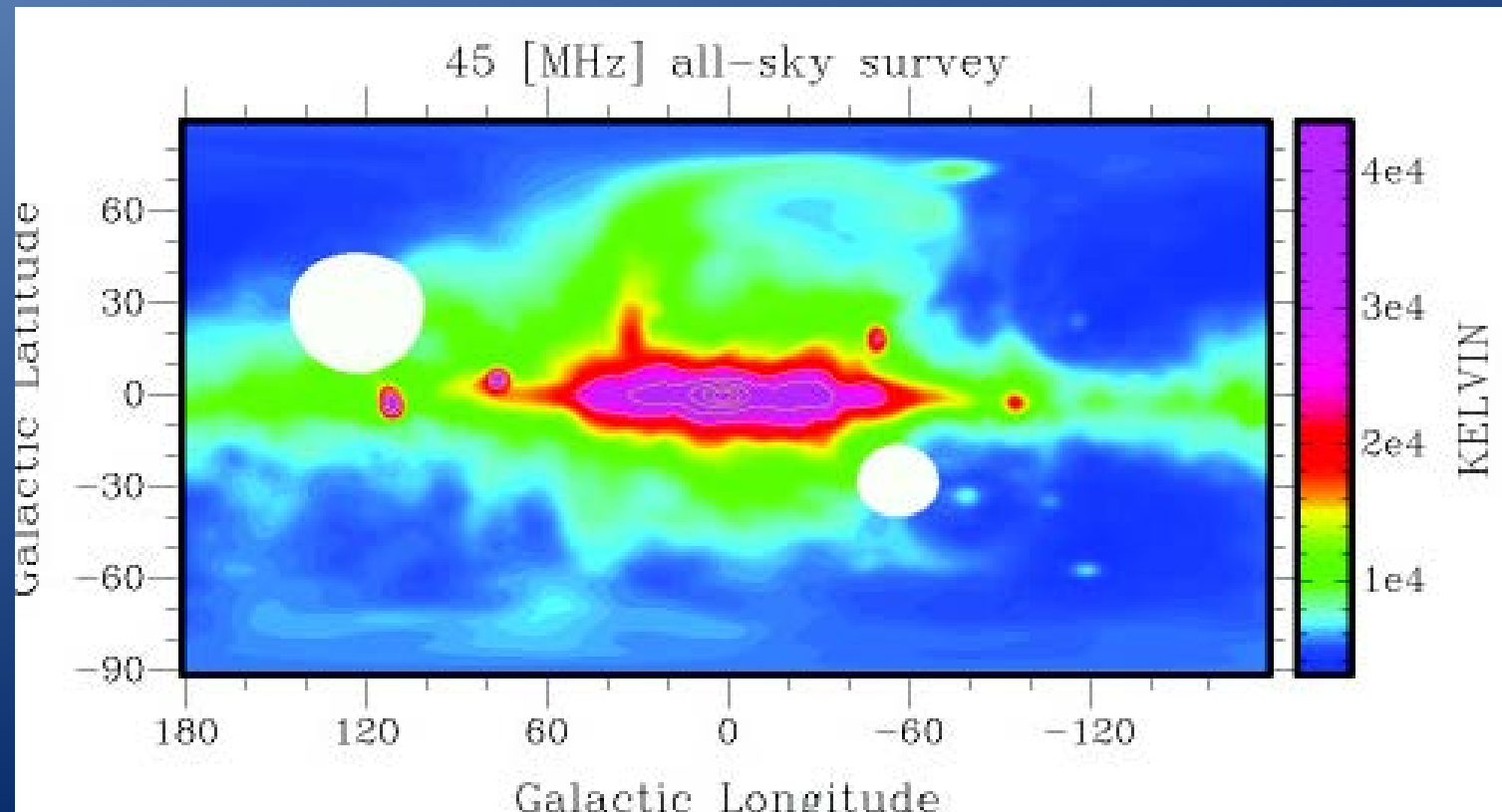
Leonardo Bronfman

HISTORY

Maipú Radio Observatory (45 MHz, 1959-2000)
First in Latin America, model for radio band protection.



- Complete map of the sky at 45 MHz
- N. Hemisphere observed from Japan (K. Maeda, Hyogo U.)
- Lowest frequency full-sky map (Guzmán, May et al. 2011)



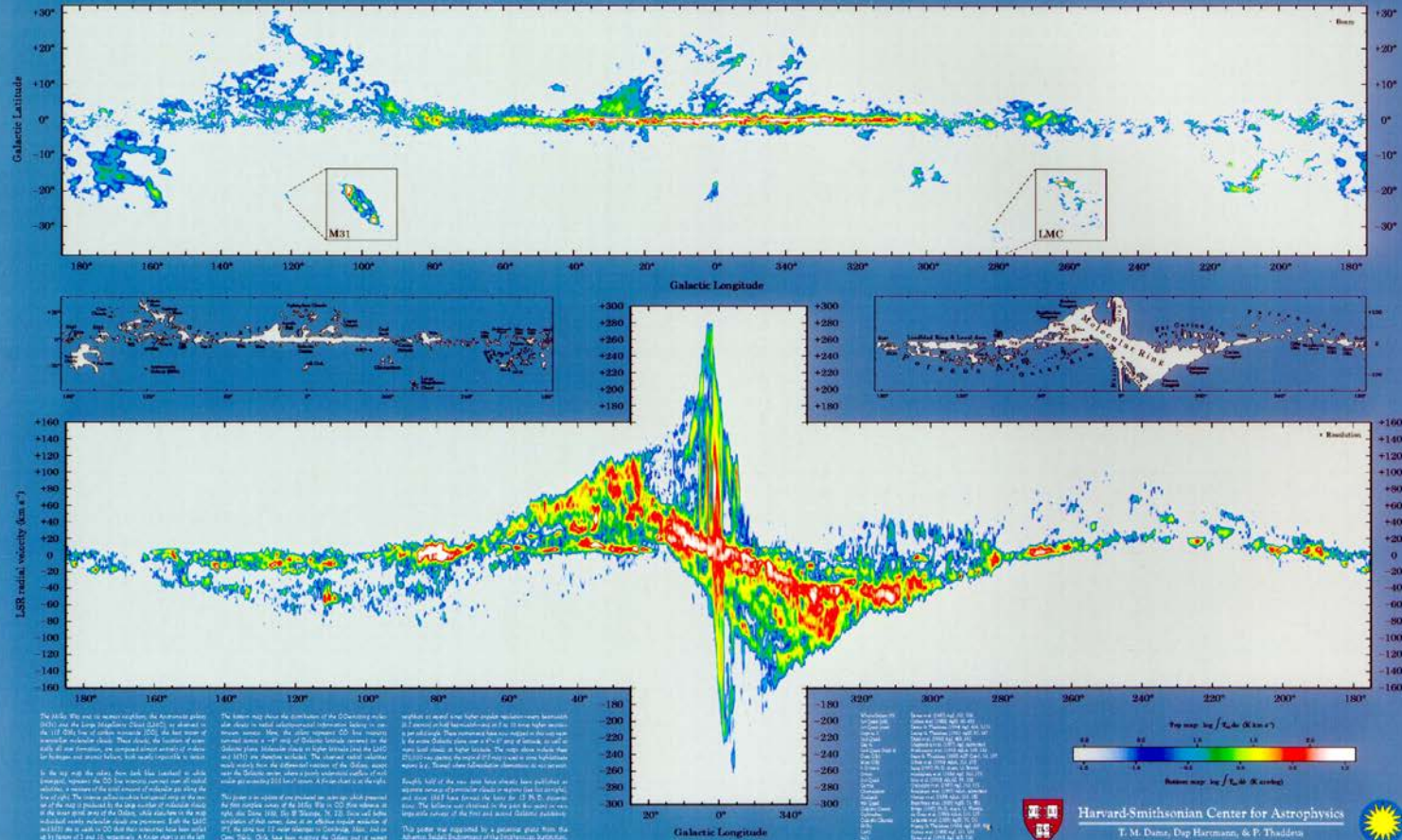
1.2 m Southern Mm-wave Telescope (86 -115 GHz)

- Columbia U. / U. de Chile (Cerro Tololo 1982).
- First dedicated mm-wave telescope in the Southern Hemisphere
- Moved to C. Calán, U. Chile campus (2005-2009)



First complete CO survey of the Galaxy

The Milky Way in Molecular Clouds



The U. Chile Millimetre Wave Laboratory (2005)

CATA (2008)



- Joint effort of Astronomy and Electrical Engineering.
- Development of front-end and digital back-end technology
- Training of undergrad and grad students (joint PhD program)
- International collaboration in state-of-the-art projects: ALMA

CATA ASTRONOMICAL INSTRUMENTATION



Leonardo Bronfman
Professor



Patricio Mena
Associate Professor



Ernest Michael
Associate Professor



Nicolas Reyes
Assistant Professor



Ricardo Finger
Assistant Professor



Valeria Tapia
M.Sc.



Rafael Rodriguez
PhD



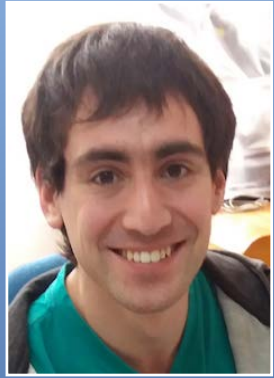
Claudio Jarufe
PhD Student



Daniel Montofré
PhD Student



Jose Pizarro
Mechanical Engineer



Franco Curotto
MSc Student



Ignacio Barrueto
MSc Student



Rocío Molina
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Francisco Navarrete Engineer



David Monasterio
Engineer



Pablo Astudillo
Engineer



Camilo Avilés
Mech. Engineer



Roberto Fuentes
Eng. Student



Nicole Díaz
Eng. Student



Christopher Muñoz
Eng. Student



Francisco Casado Eng.
Student



MM-WAVE LAB AND MACHINE SHOP:

ORIGINAL CATA INVESTMENT	USD 600.000
QUIMAL, AIC27, FONDEQUIP	USD 600.000
ALMA, ESO, GEMINI (CONICYT)	

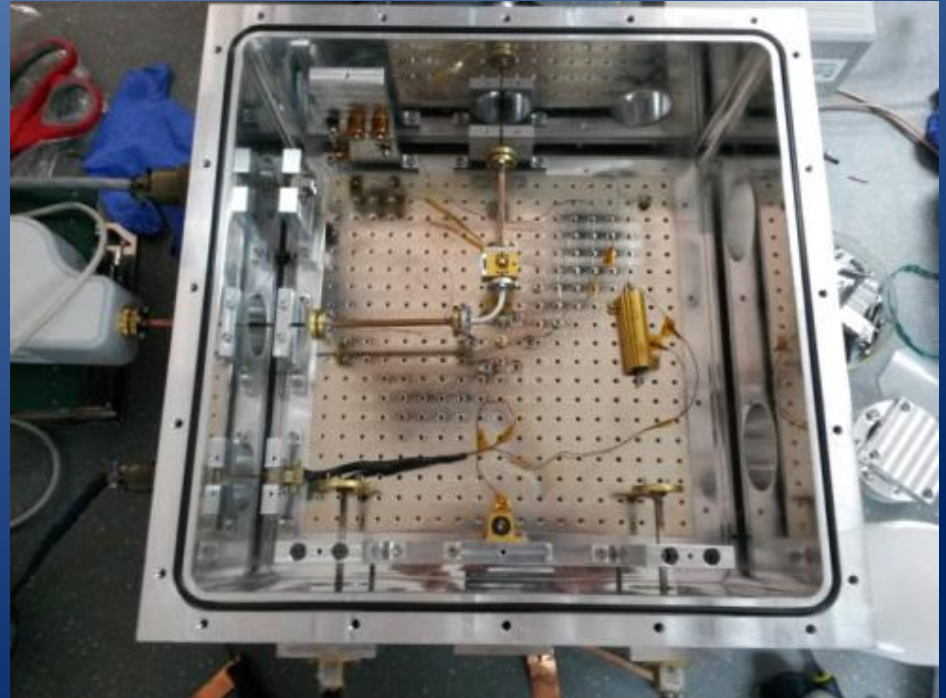
ALSO:PHOTONICS LAB AT FCFM

QUIMAL 2015

Mm-Wave Laboratory-Cryogenics



ALMA compatible cryostat (NAOJ)



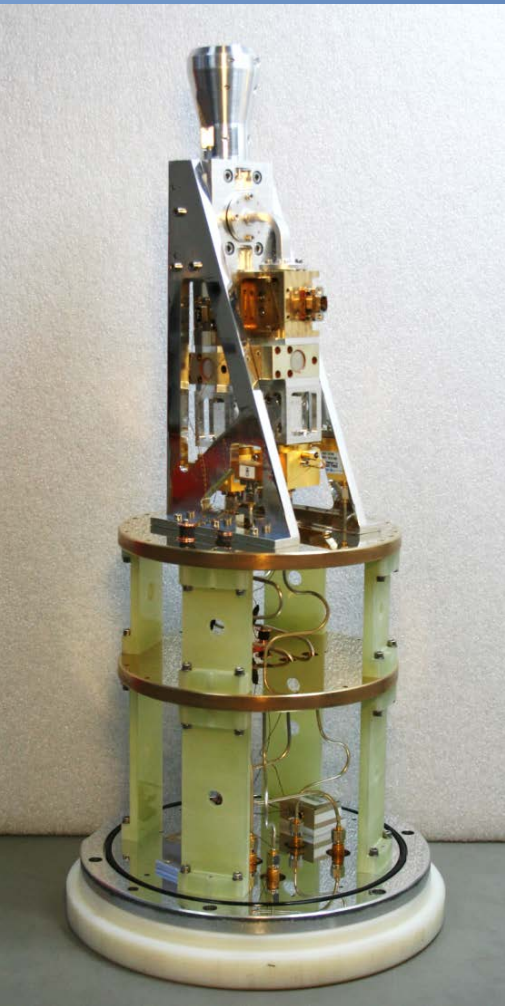
Homemade cryostat for component testing

Main Current Projects

1. ALMA Band 1 Optics full design and fabrication
2. ALMA Band 2+3 Optics design and prototype
3. LLAMA Bands 1 and 3 Heterodyne Receivers (Arg, Br)
4. FPGA-based Digital Signal Processing (ALMA Band 9, SRON; FAST 500 m, CAS)
5. Sub-mm detector arrays (CCAT-p, Cologne); starting
6. Fiber based IR Interferometry (Photonics Lab. FCFM)
7. Innovation and technology transfer

1.- ALMA Band 1 (35-52 GHz) Receiver: Flagship project

- Phase 1: Receiver prototype (CATA 2008-2012)
- Phase 2: Design and Production of 77 receivers (Taiwan; Canada; Japan; US)
- **Chile WP: Optics**



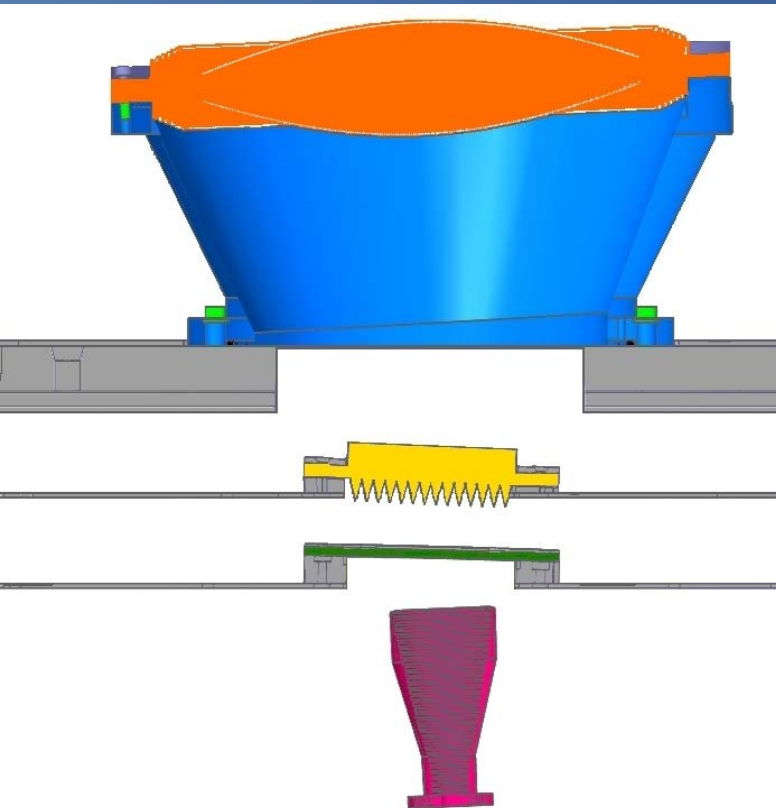
CONSTRUCTION APPROVED BY ALMA BOARD ON 23 MAY 2016

ALMA Band 1

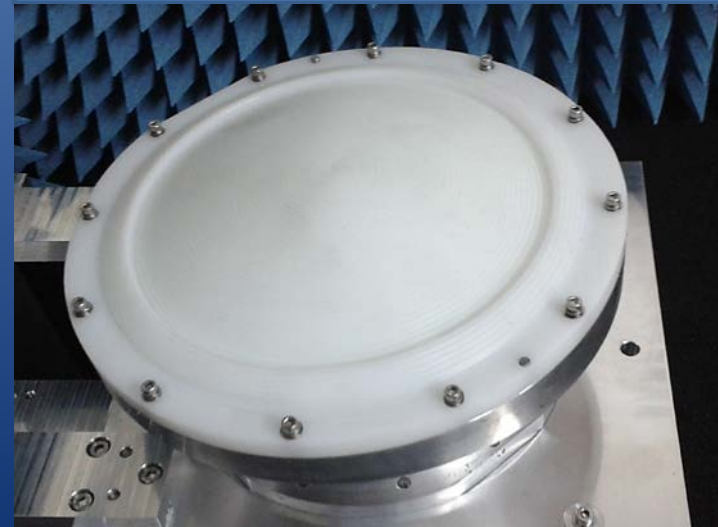
“High efficiency wideband refractive optics for ALMA Band-1”;

Tapia et al. 2016, J Infrared Mm Terahertz Waves

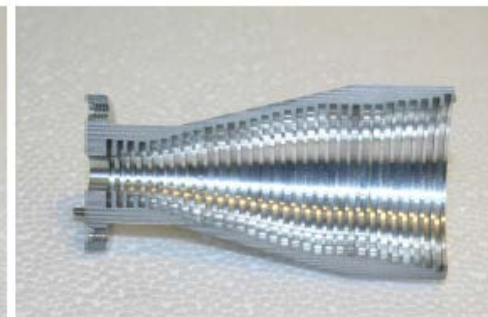
77 units of the ALMA Band 1 (35-52 GHz) optical system are being built by CATA after own prototype design.



Bi-hyperbolic zoned Fresnel lens



Optimized-profile corrugated horn

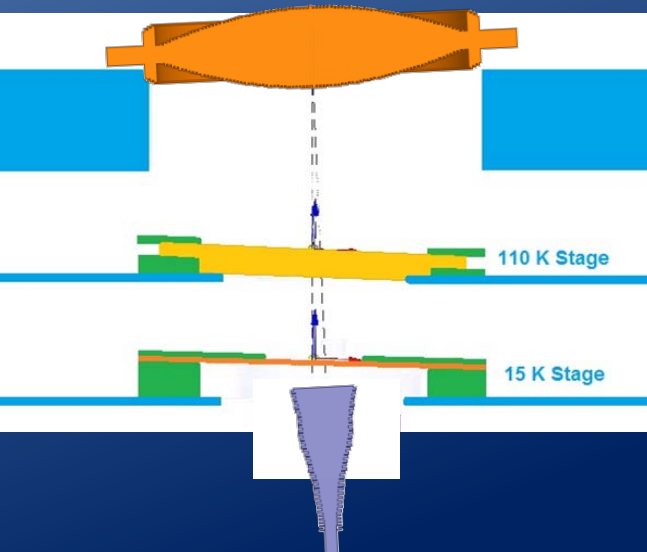


2.- ALMA Band 2+3 Receiver (67-116 GHz):

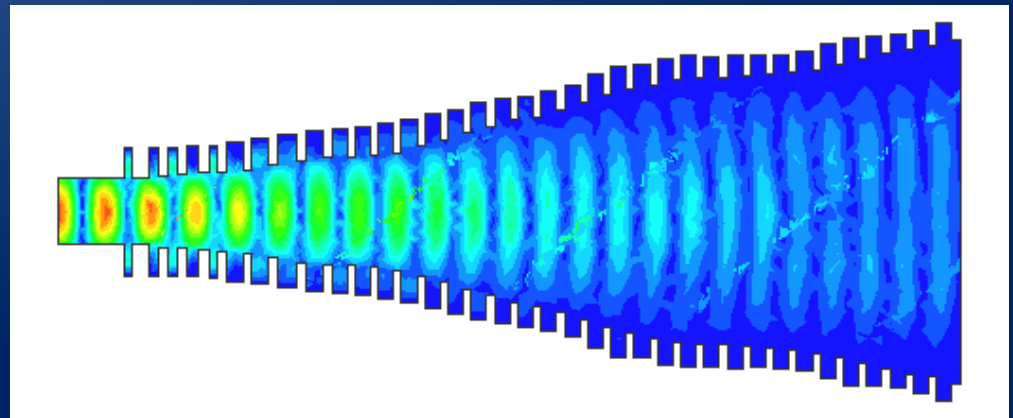
Development of a prototype within consortium: ESO, IRAM, Manchester, Arcetri, NAOJ, U. Chile (Optics)

- a) Electromagnetic and mechanical models of components.
- b) Construction and testing of components and assembly of the entire system.

Optics general view



Simulated E field inside horn for a 67 GHz excitation.



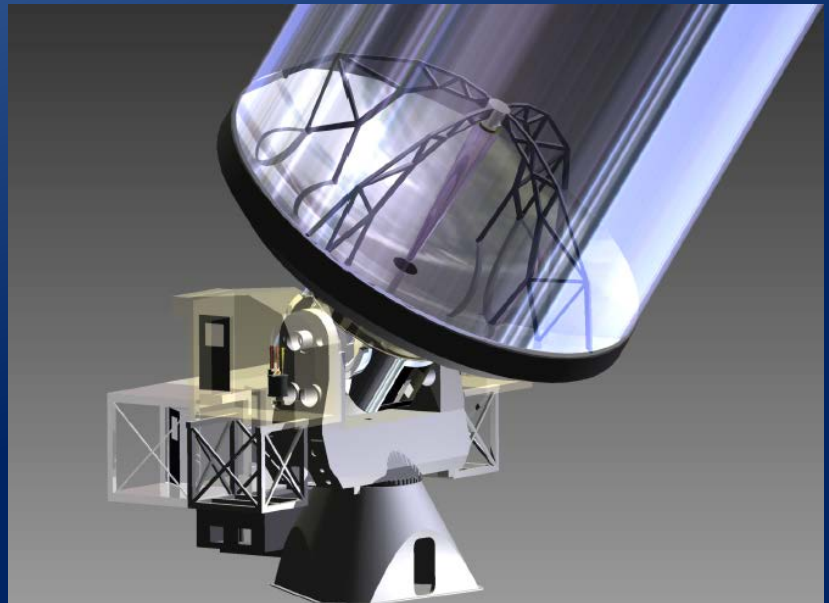


3. The Large Latin American Millimeter Array (LLAMA)

- Argentina-Brazil 12m sub-mm telescope in N. Argentina
- U. Chile: receiver for Band 1
- Receiver for Band 3 (UdeC, R. Reeves; CalTech, LNA)

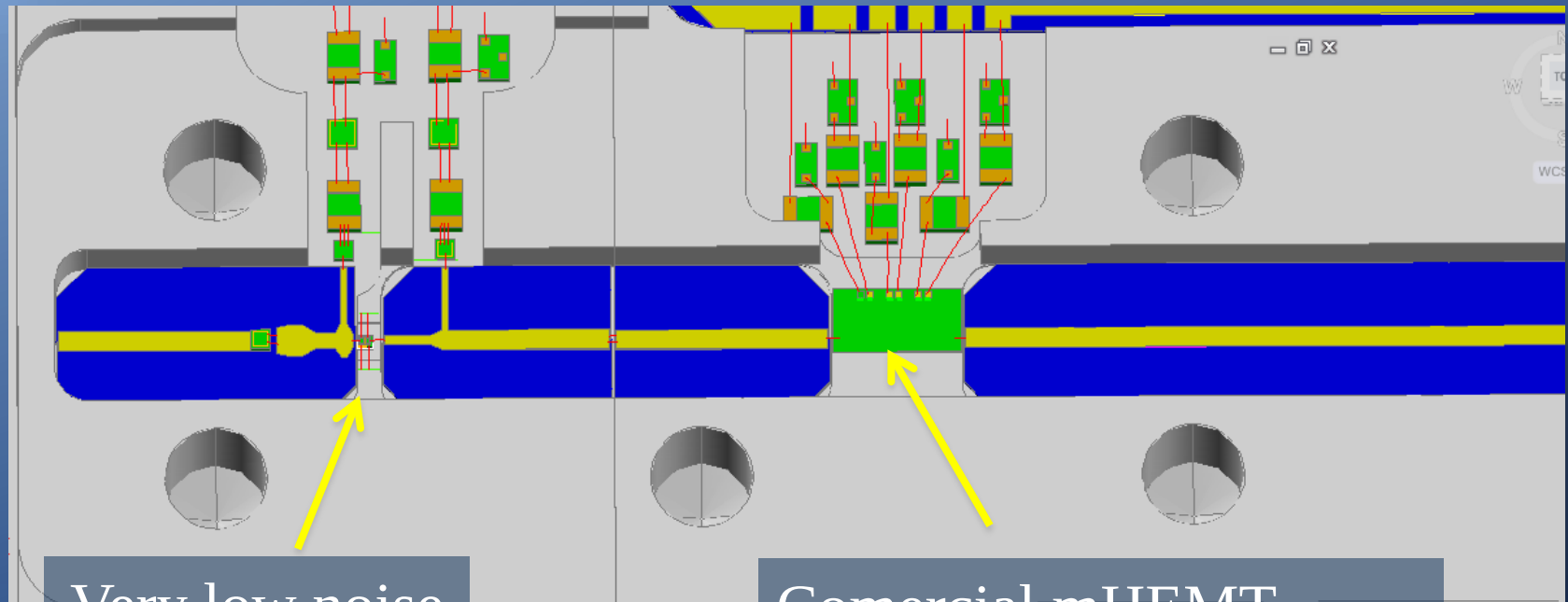


LLAMA location (183 Km from ALMA, 4755 MASL)



LLAMA 3D model

LLAMA Band 1: Hybrid LNA Development



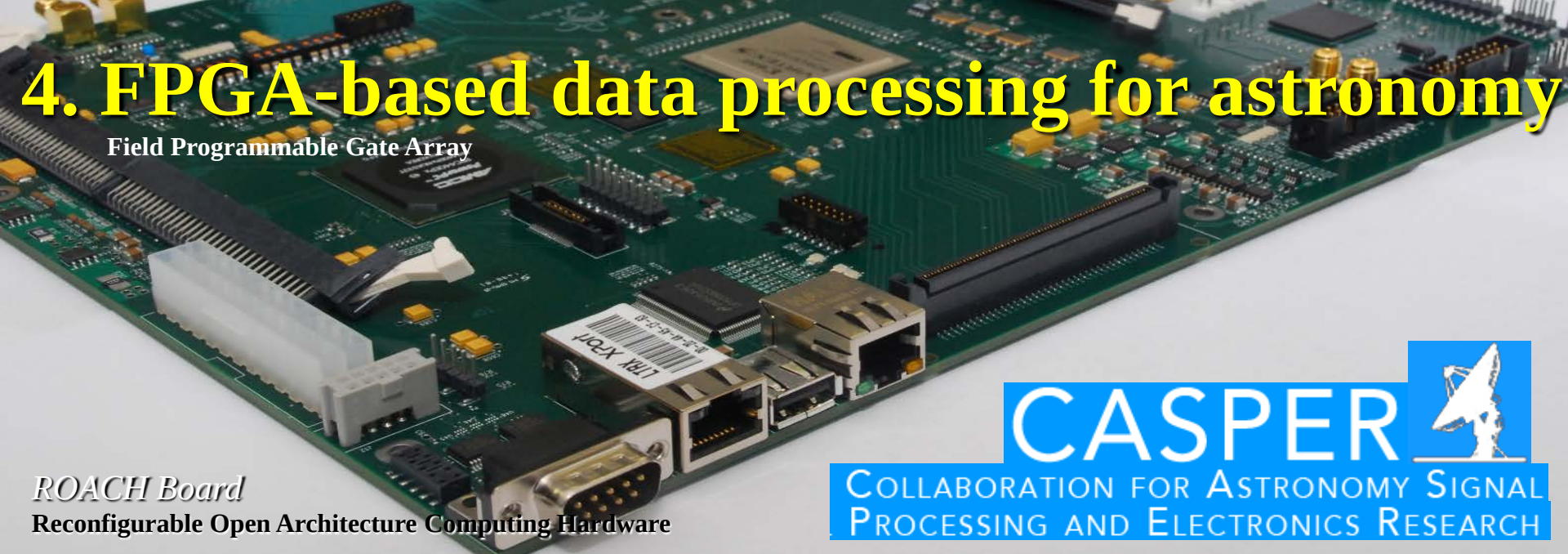
Very low noise
InP Transistor

Comercial mHEMT
GaAs MMIC

Pros:

Claudio Jarufe (PhD)

1. More compact and easy to manufacture
2. Suitable for multipixel or other very-compact designs
3. Cheaper than only-transistors amplifiers, but with similar performance.



4. FPGA-based data processing for astronomy

Field Programmable Gate Array

ROACH Board

Reconfigurable Open Architecture Computing Hardware

CASPER



COLLABORATION FOR ASTRONOMY SIGNAL
PROCESSING AND ELECTRONICS RESEARCH

- Field Programmable Gate Arrays: Novel way to process astronomical signals digitally.
- Digital Sideband separation (ALMA Band 9, SRON)
- Real Time Radio Frequency Interference Mitigation (FAST 500 m Telescope, CAS)

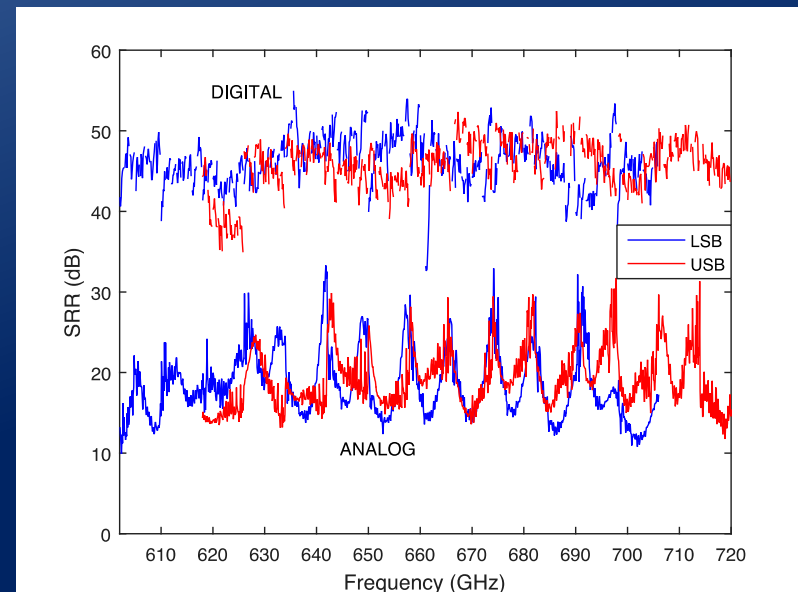
DIGITAL SIGNAL PROCESSING HIGHLIGHTS

“Ultra-pure digital sideband separation at sub-mm wavelengths”.

Finger et al. 2015, A&A; Rodriguez et al. 2014, PASP

- ALMA Band 9 (602–720 GHz) currently double sideband (DSB)
- Analog Side-band separating prototype receiver built at SRON, Netherland
- CATA FPGA 2SB digital back-end interfaced with SRON prototype.

- SB rejection ratio 1000 times better using CATA digital backend



6. Photonics Lab: Fiber-based Infrared Interferometry

- Now: 2-telescope proof-of-principle at $1.55\text{ }\mu\text{m}$
- Vision: cover the entire $8\text{-}13\text{ }\mu\text{m}$ range using commercial fibers

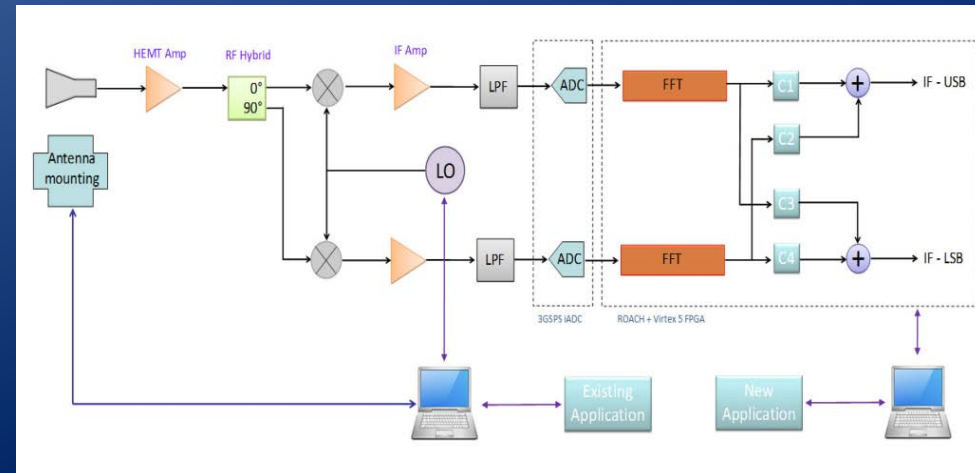
Future plan: build a demo in a Chile observatory: e.g. TAO



Training facility:

The 1.2 m Southern Mm-wave Telescope (Mini)

- Hands-on training for students of engineering and astronomy courses.
- Test bench for new technologies.
- Many engineering degrees and 2 PhD theses.
- Front-End and digital Back-End upgrades.

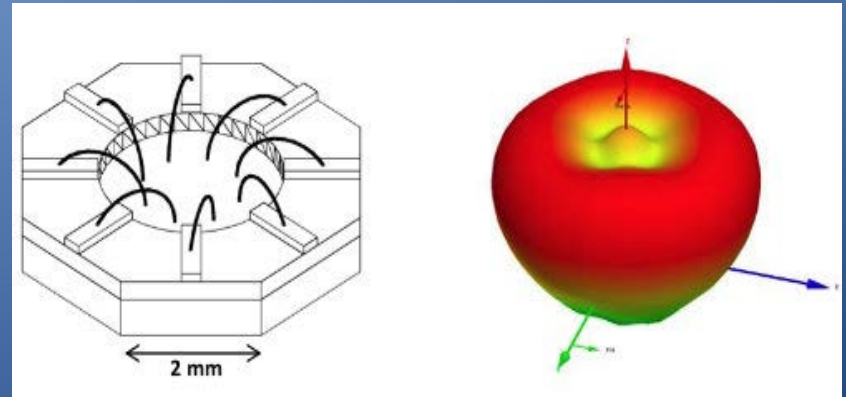


Digital sideband separating mixer using FPGA technology (ROACH).

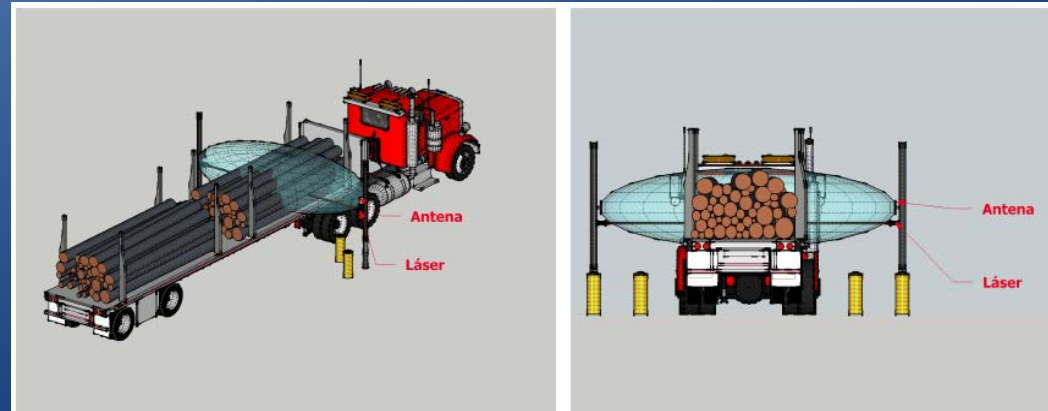
Southern Mini at Cerro Calán

7.- INNOVATION AND TECHNOLOGY TRANSFER

Bond wire array antenna
prototype for in-door 60 GHz
communications



Measurement of wood
moisture content using
microwave transmission



Radio-Vision: portable
camera allowing localization
of mobile phones. Prototype
already working.



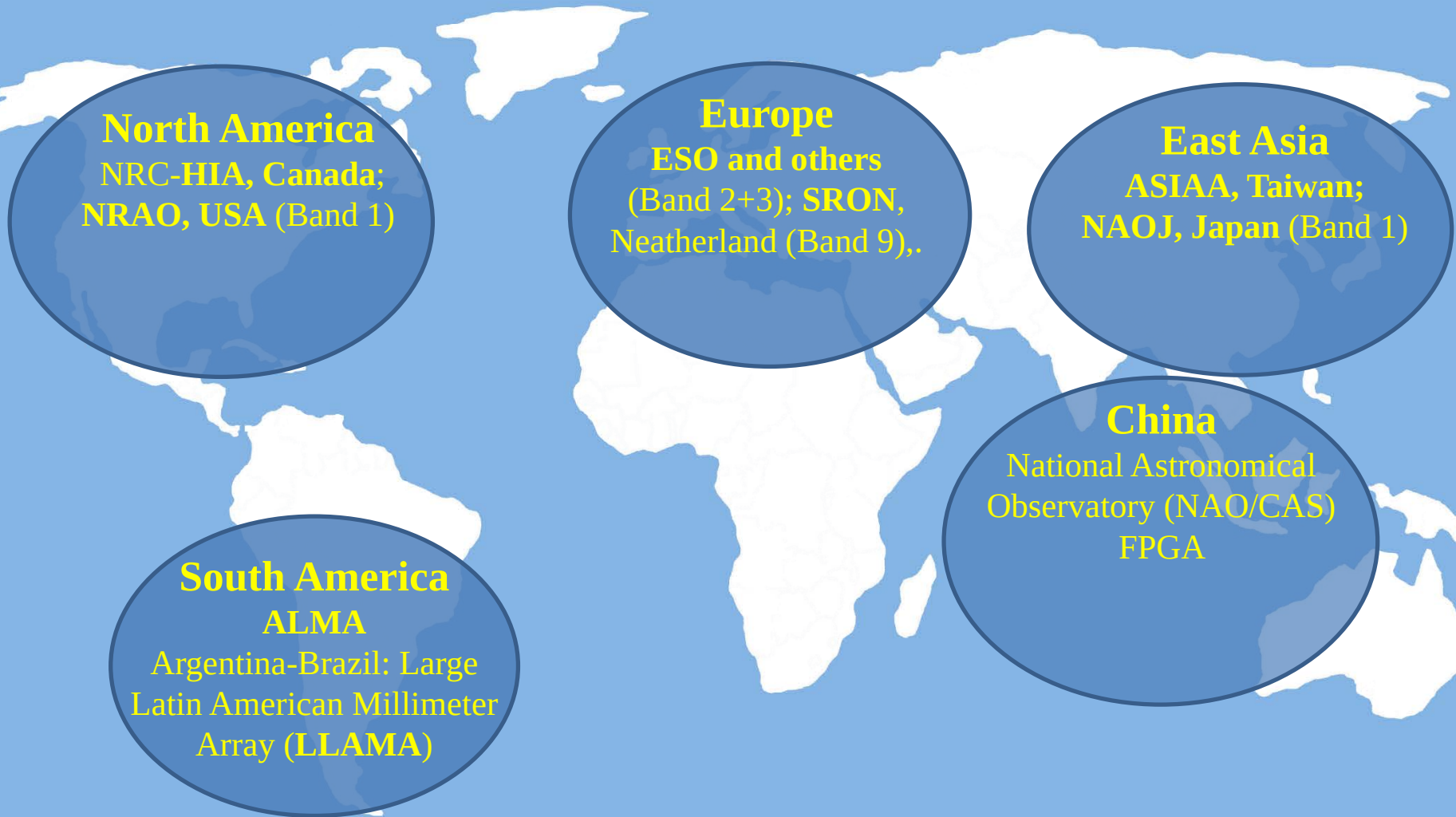


U. Chile Astronomical Instrumentation in numbers



Aspect	Baseline	CATA U. Chile outcome
Graduate students	No graduate program in Astronomical Instrumentation	Joint PhD (DAS-DIE): 5 PhD graduated, 2 ongoing, 2 MSc graduate, 3 ongoing
Undergraduate Students	No Major in Astronomical Instrumentation	14 Undergraduates theses (EE, Mec.E, Chem.E); 4 ongoing
Publications	20 years since last paper in Astronomical Instrumentation	7 ISI papers since 2011, > 15 conference papers
Internships in Chile	---	7 Internships completed (Argentina, Ecuador, France, Netherlands, Japan, China)
Internships abroad	---	All graduate students perform international internships
New professors	3 professors	2 new assistant professors (Faculty of Phys. and Math. Sciences, 2013) 1 New academic insertion in Astronomy (CONICYT, 2017)

International Collaborations



Thanks!

