Cerro Calán
Observatorio Astronómico Nacional

UNIVERSIDAD DE CHILE

INGENIERIA ELECTRICA
FACULTAD DE CIENCIAS
FÍSICAS Y MATEMÁTICAS
UNIVERSIDAD DE CHILE

Chile, The Capital of Observational Astronomy.

Ricardo Finger
Department of Astronomy
University of Chile

Atacama: The driest desert in the world

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University of Chile

First observatories in northern Chile

1966 Cerro Tololo Interamerican Observatory (NOAO)

1969 European Southern Observatory La Silla (ESO)

Observatories in northern Chile

1971 Las Campanas Observatory (Carnegie)

2002 Gemini Observatory (AURA++)

Twin telescopes (Chile-Hawaii)

Observatories in northern Chile

1998 Very Large Telescope VLT (ESO)

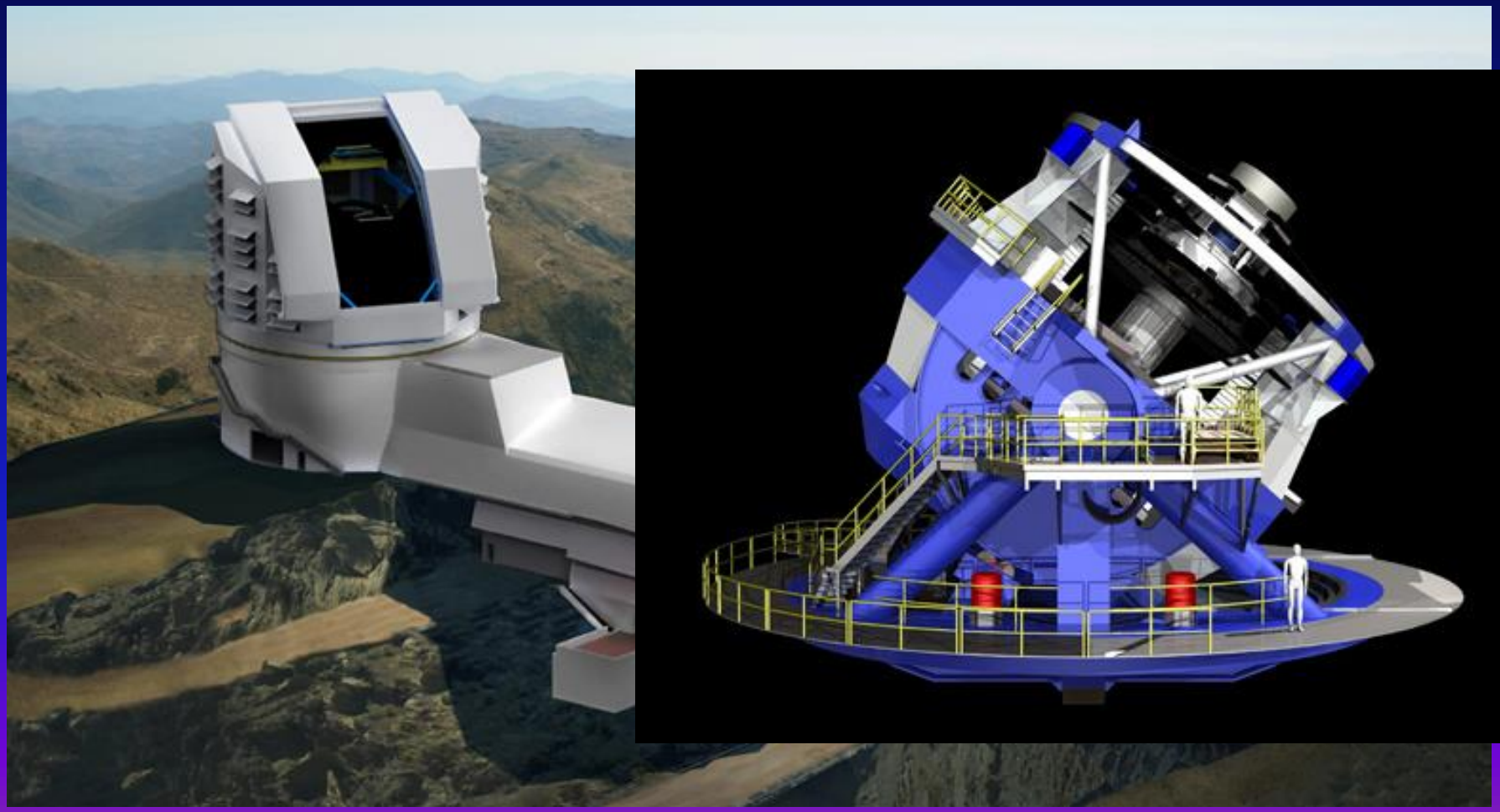
2005 APEX (Max Planck, Onsala, ESO)

ASTE (NAOJ, UTokyo++)

2012: Atacama Large Millimeter/submillimeter Array ALMA (NRAO/ESO/NAOJ)

Future facilities

Large Synoptic Survey Telescope (LSST) - 2019 -



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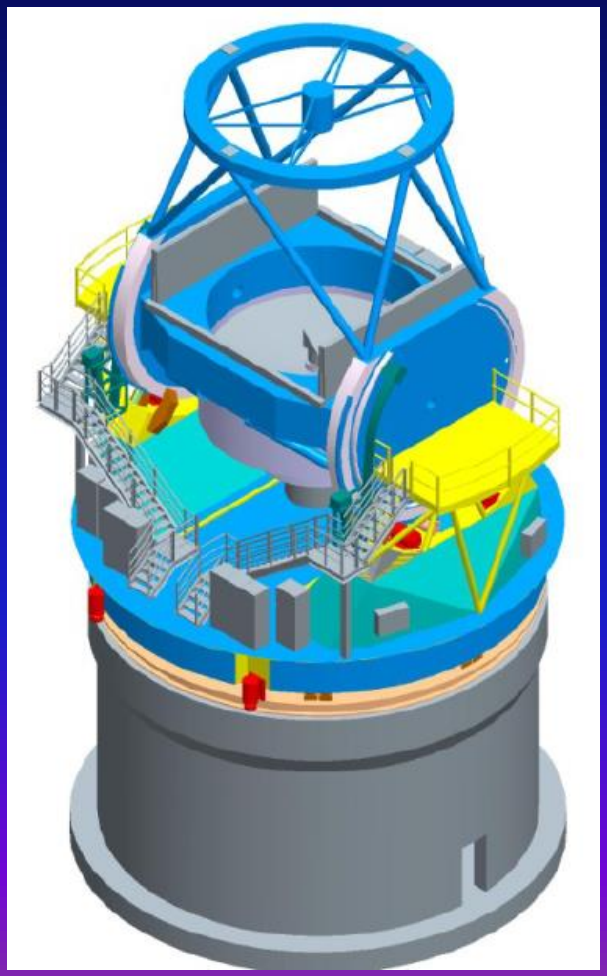
Future facilities

- University of Tokyo Atacama Observatory (TAO)
- A 6.5m optical-infrared telescope at **5640m** of altitude at Cerro Chajnantor (Highest ground-based observatory)



Mini-TAO

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Future facilities

E-ELT 39 m telescope at Cerro Armazones (ESO) - 2025 -

Future facilities

Giant Magellan telescope (24.5m) at cerro Las Campanas (2020)

Future facilities

CCAT

Cornell- Caltech Atacama telescope
25m Submillimeter telescope
5612 MASL on Cerro Chajnantor

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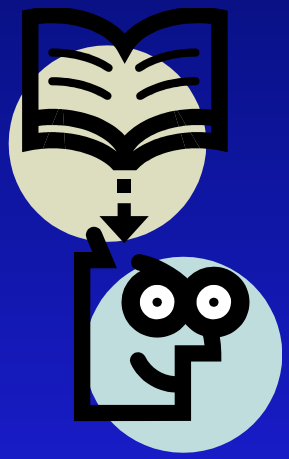
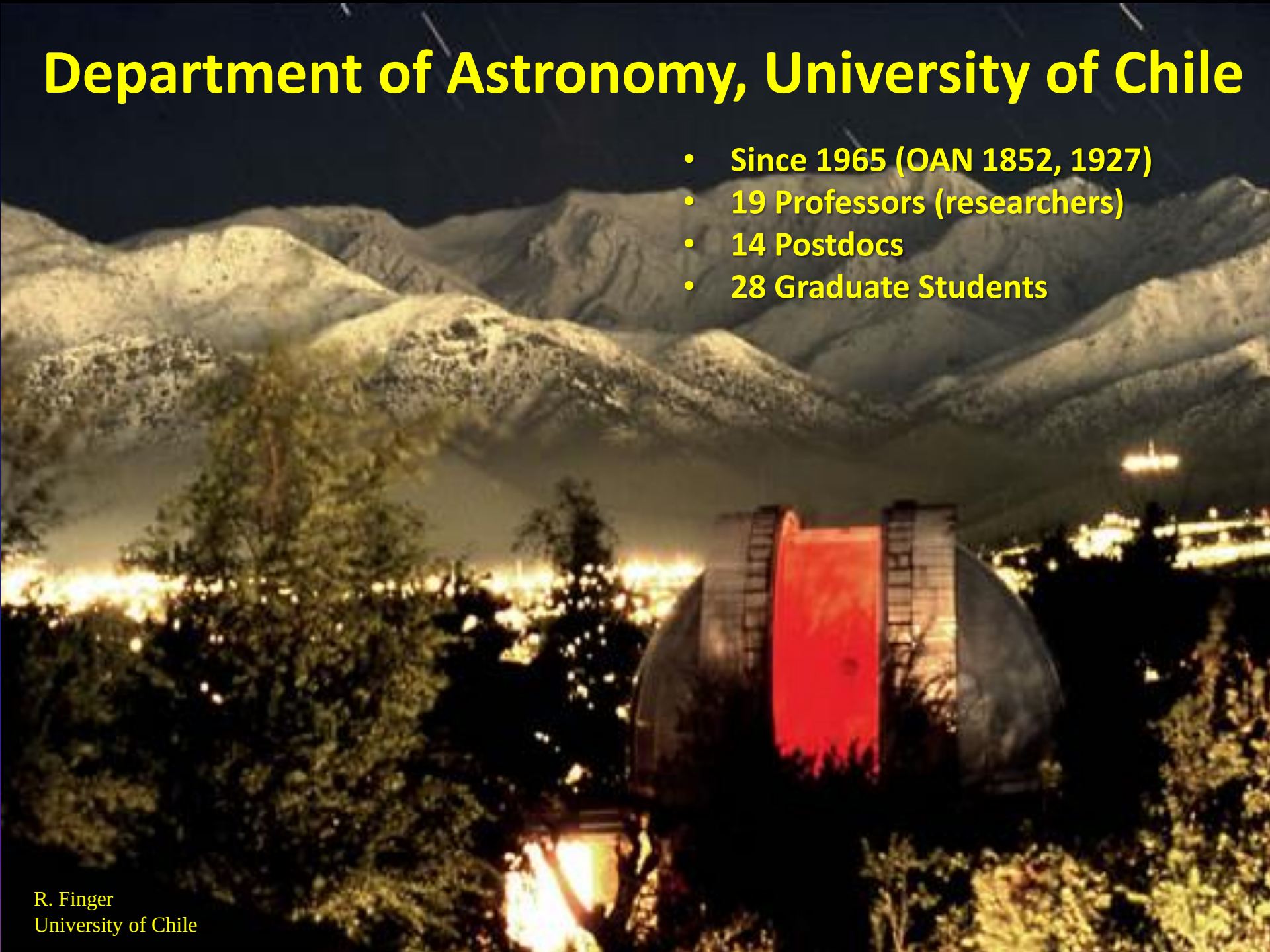
But, what are these beautiful instruments good for??



Department of Astronomy, University of Chile



- Since 1965 (OAN 1852, 1927)
- 19 Professors (researchers)
- 14 Postdocs
- 28 Graduate Students

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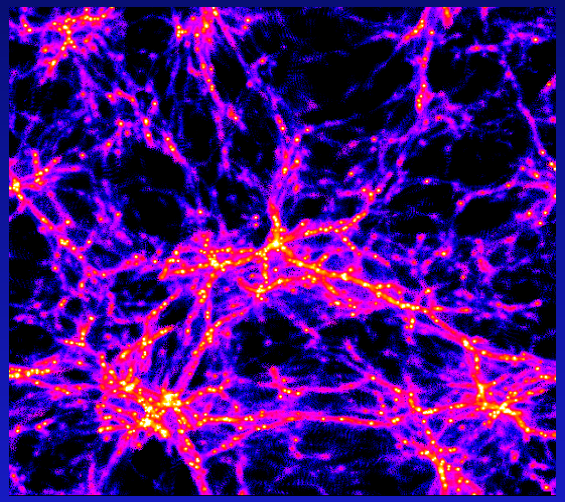
Main Areas
Cerro Calán
1. Extragalactic astronomy
2. Stellar populations in the local Universe
3. Star Formation
4. Extrasolar Planets and Brown Dwarfs
5. Supernovae and Dark Energy
6. Astronomical Instrumentation

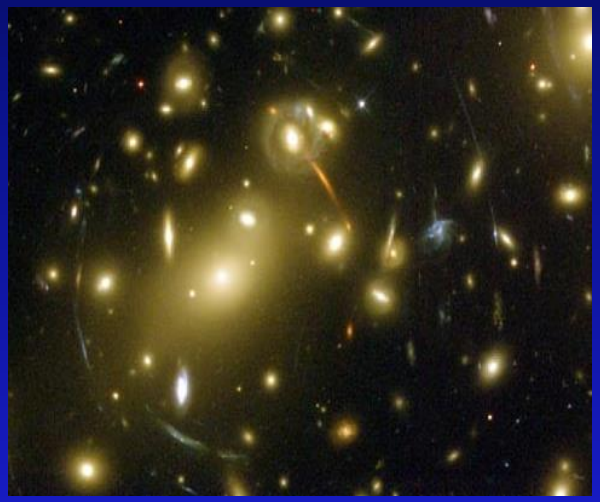
Area ①: Extragalactic Astronomy

Researchers: L. Campusano, A. Escala, P. Lira, S. Lopez, J. Maza,

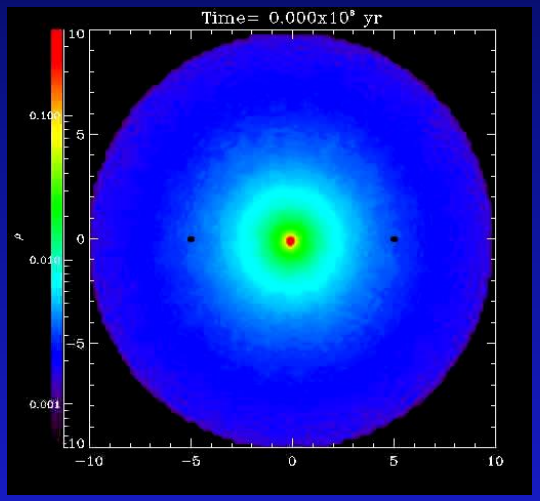
Fundamental questions:



How and when the first galaxies form?



What is the dark matter distribution in galaxy clusters?



How are massive black holes formed at the center of galaxies?

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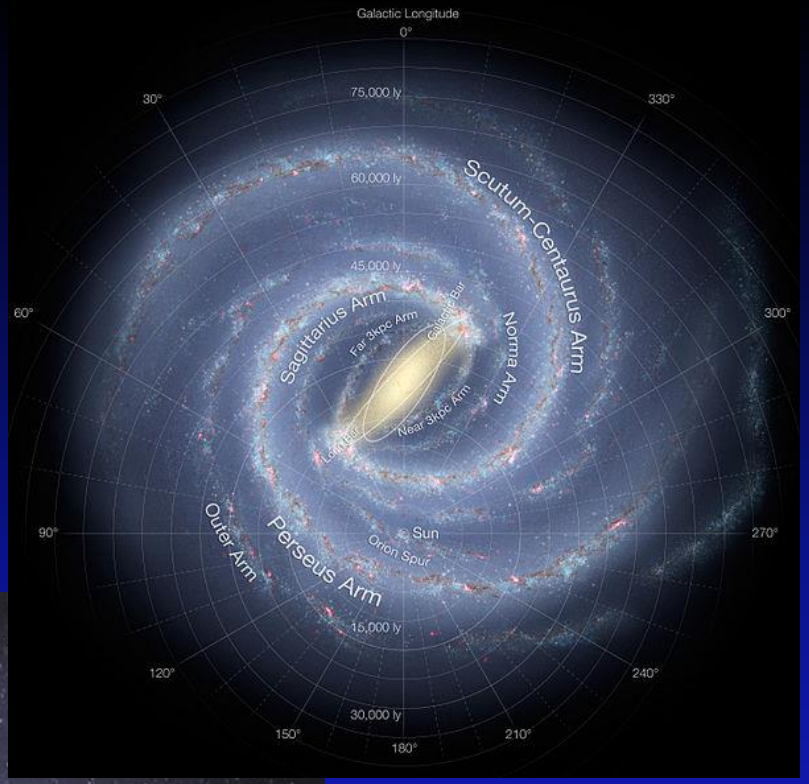
Area ②: Stellar populations in the Local Universe

Researchers: E. Costa, R. Mendez, R. Muñoz

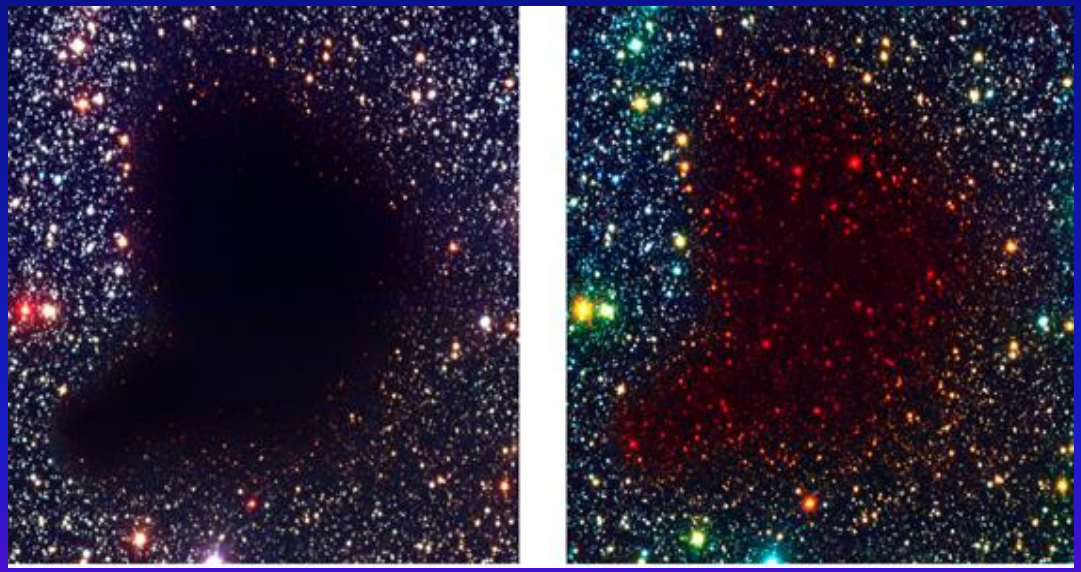
Fundamental question: How did the Milky Way formed and evolved?



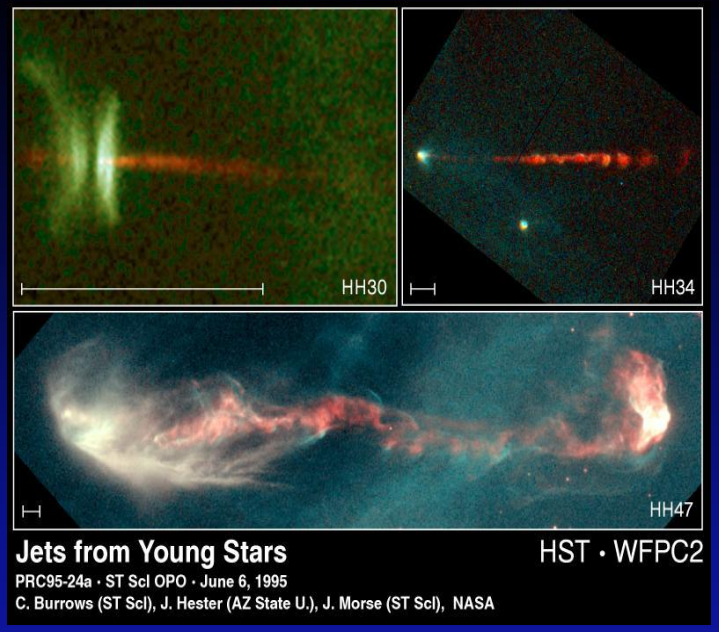
Area ③: Star Formation

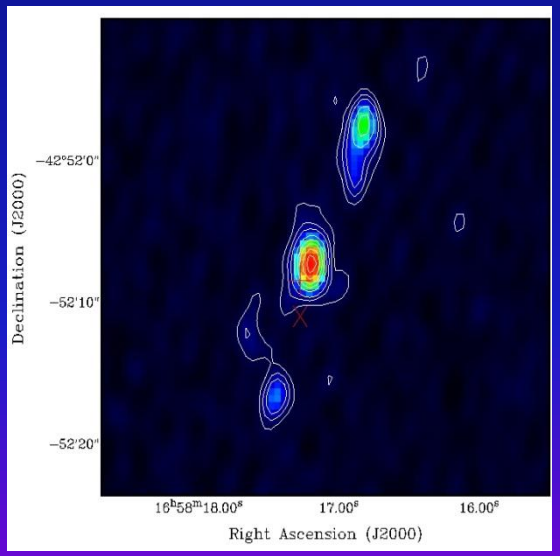
Researchers: L. Bronfman, G. Garay, D. Mardones, M. Rubio

Fundamental question: Where and how are stars formed?



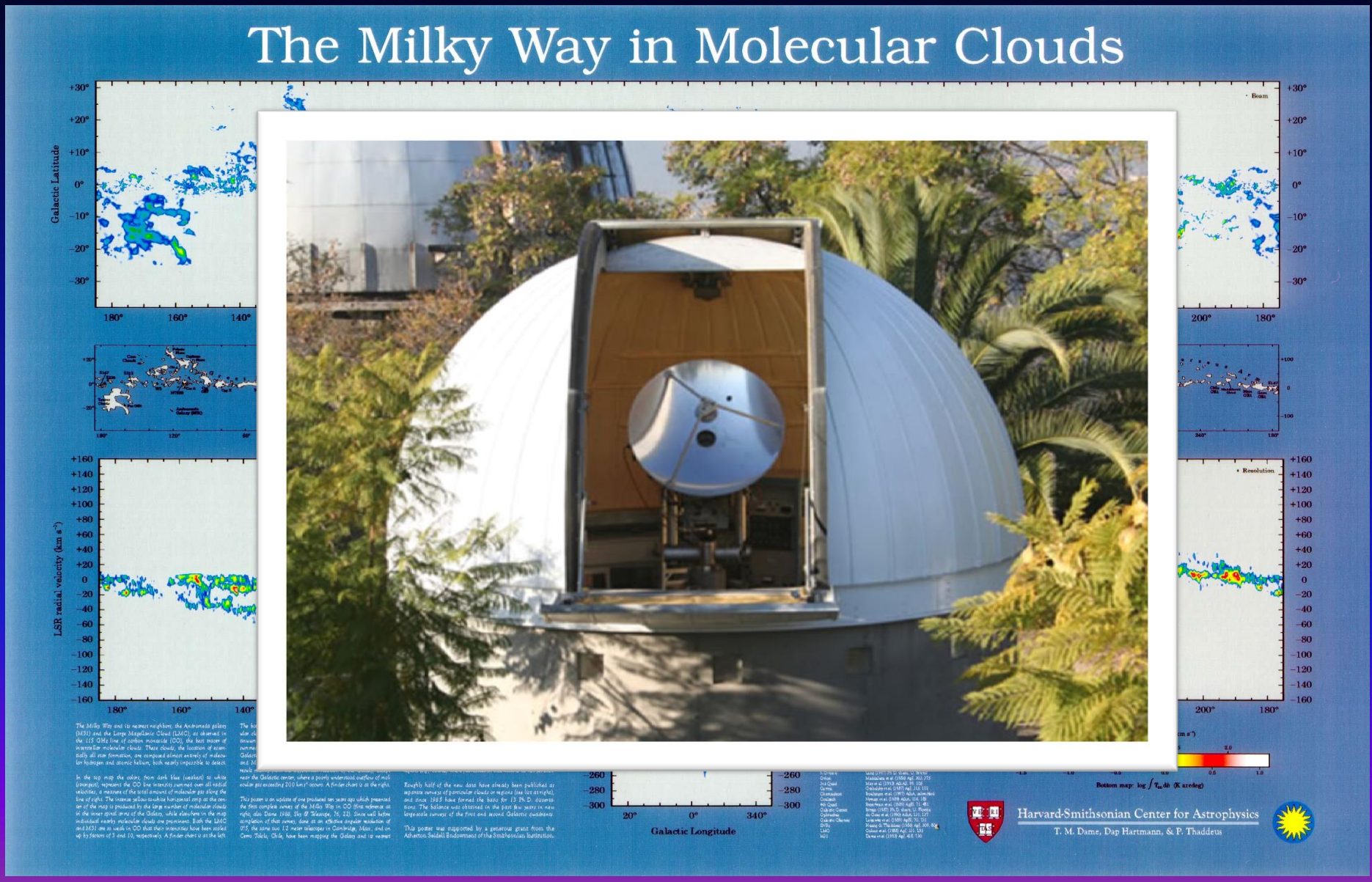
A Stellar maternity: Molecular cloud Barnard 68, about 500 ly distant and 0.5 ly in diameter.





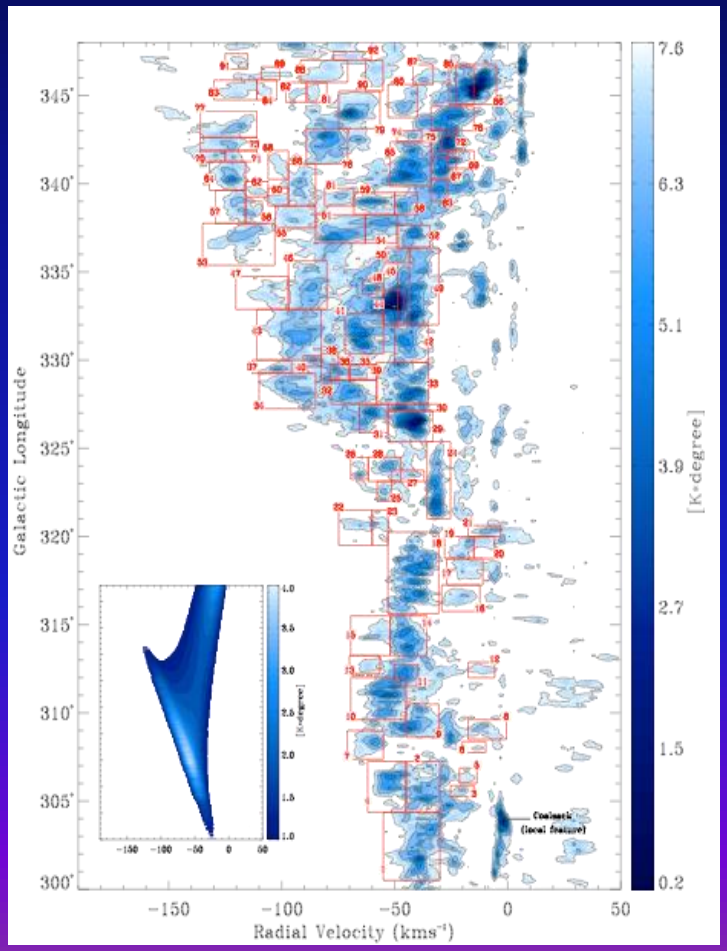
Jets of ionized gas

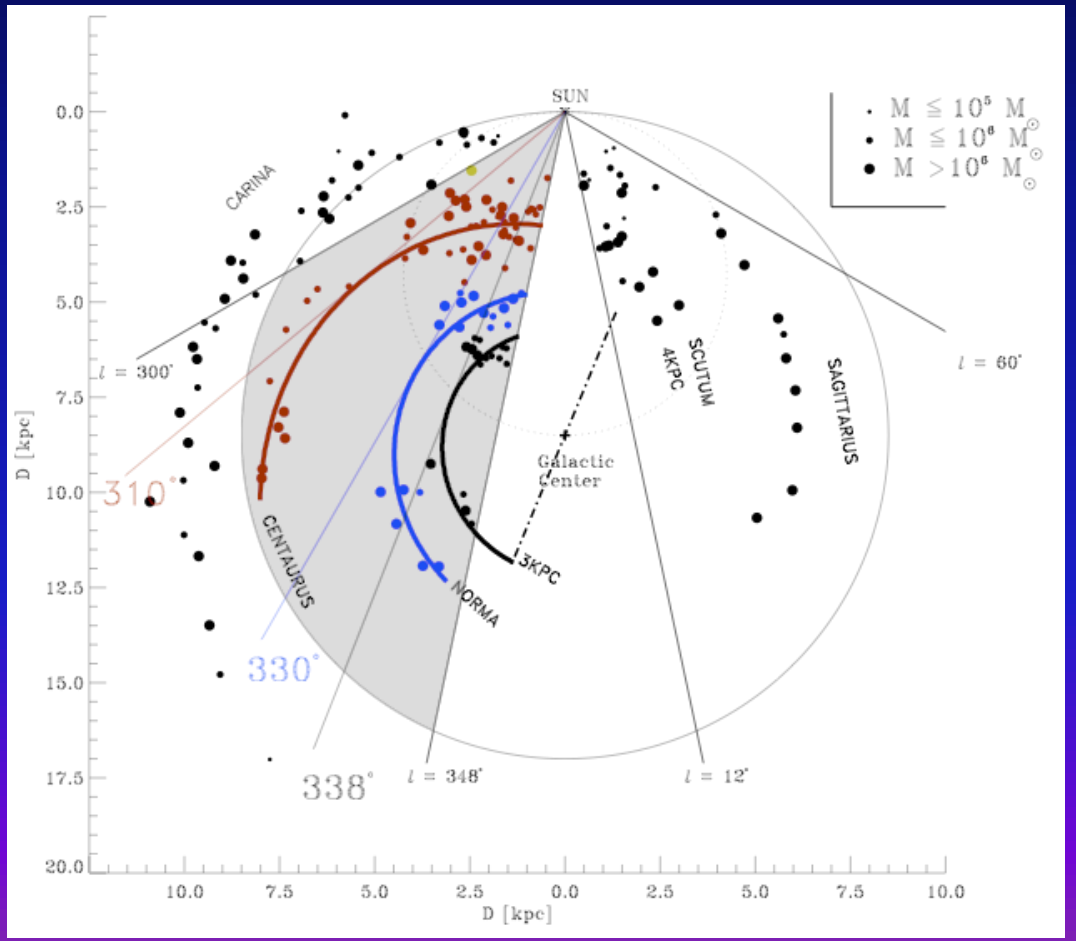
1990 : FULL MAP OF MOLECULAR GAS IN THE GALAXY. CO (J=1-0, 115 GHz) SURVEY DONE WITH THE COLUMBIA-CFA-UCHILE TWIN 1.2M TELESCOPES



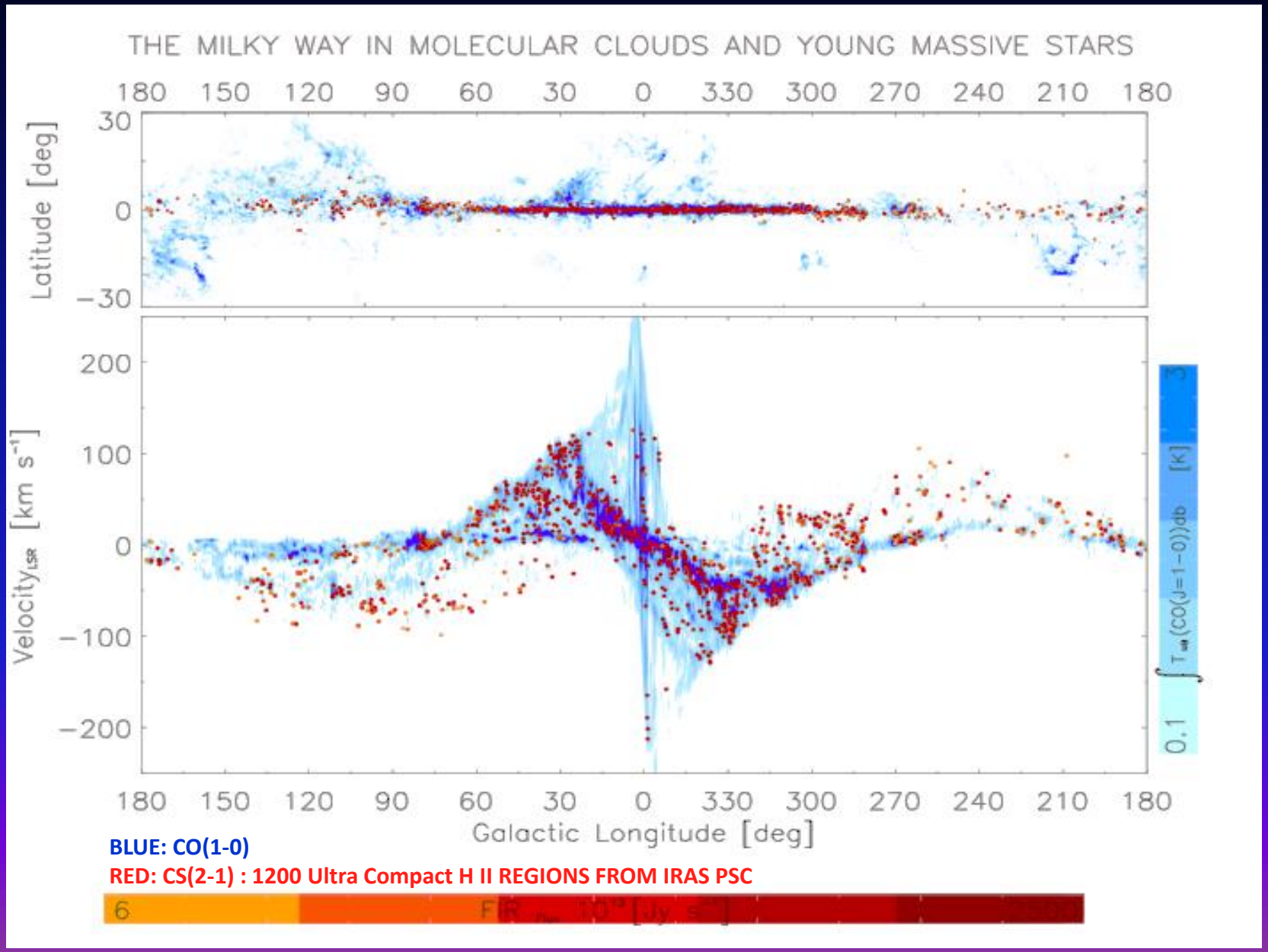
CO Survey Follow Ups: Individual Cloud Analysis

The CO emission is dominated by Giant Molecular Clouds (GMCs) which trace the spiral arms. New 4th quadrant analysis, **P. García et al. 2014.**



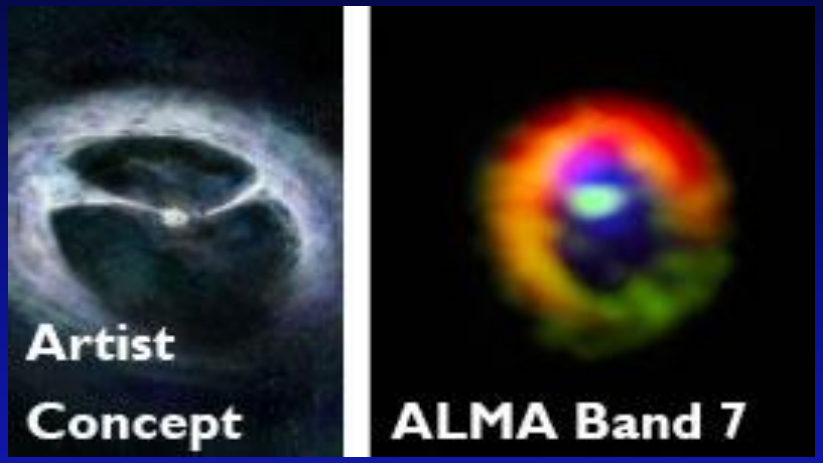


CO Survey Follow Ups: CO and start formation

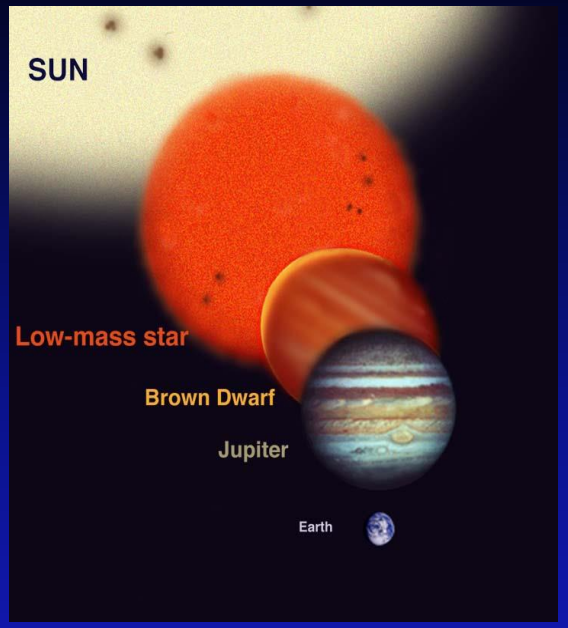


Area ④: Extrasolar planets and brown dwarfs

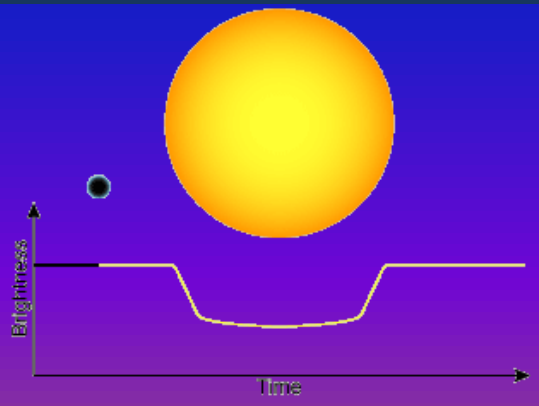
Researchers: S. Casassus, E. Costa, J. Jenkins, P.Rojo, M.T. Ruiz

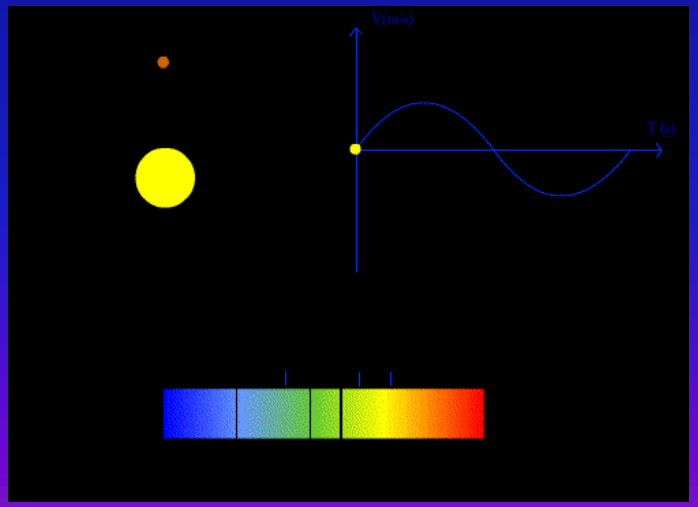


Protoplanetary disk around the young and relatively nearby star HD142527



Planet transit method

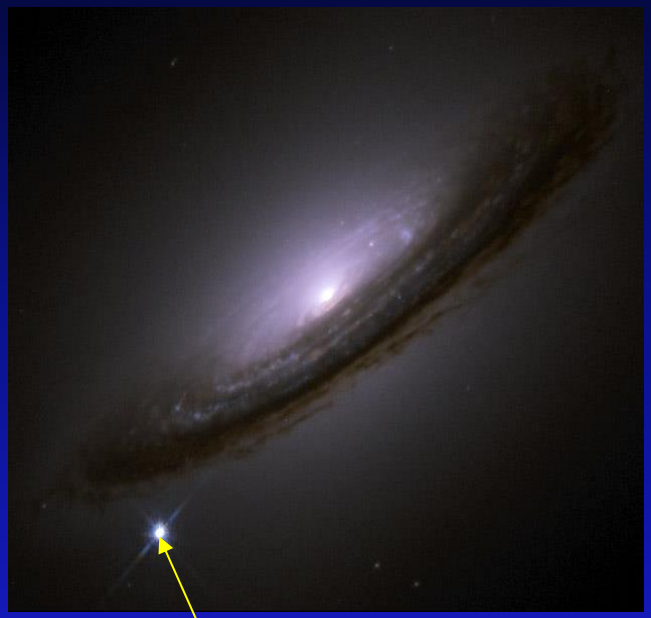




Radial Velocity Method

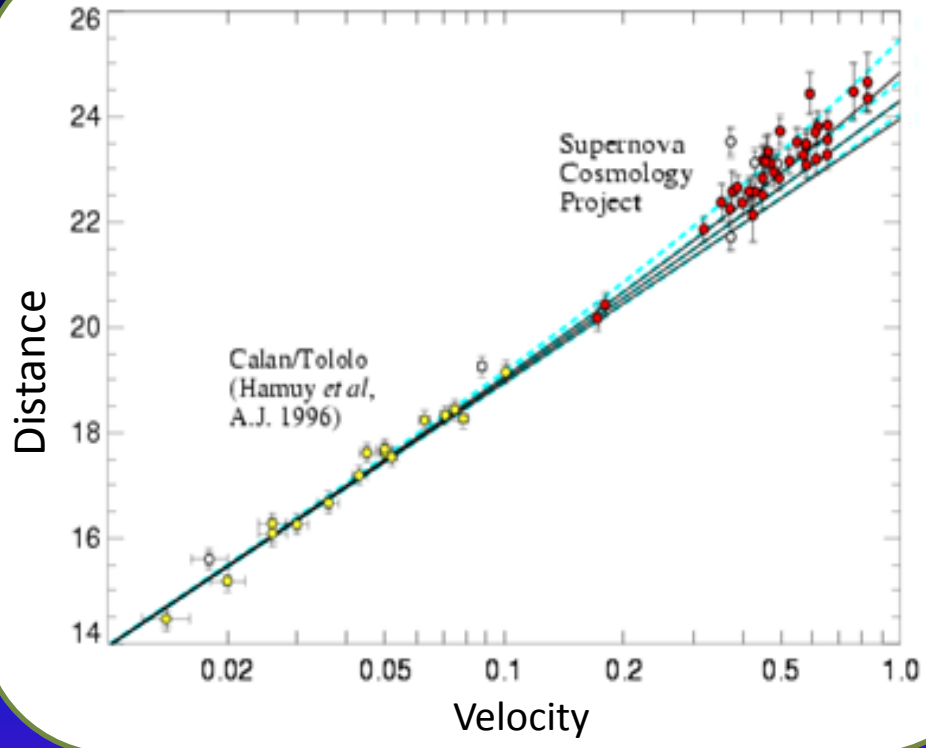
Area ⑤: Supernovas and Dark Energy

Researchers: M. Hamuy, J. Maza



supernova ⇨ velocity and distance to the host galaxy.

Distance-Velocity Diagram:

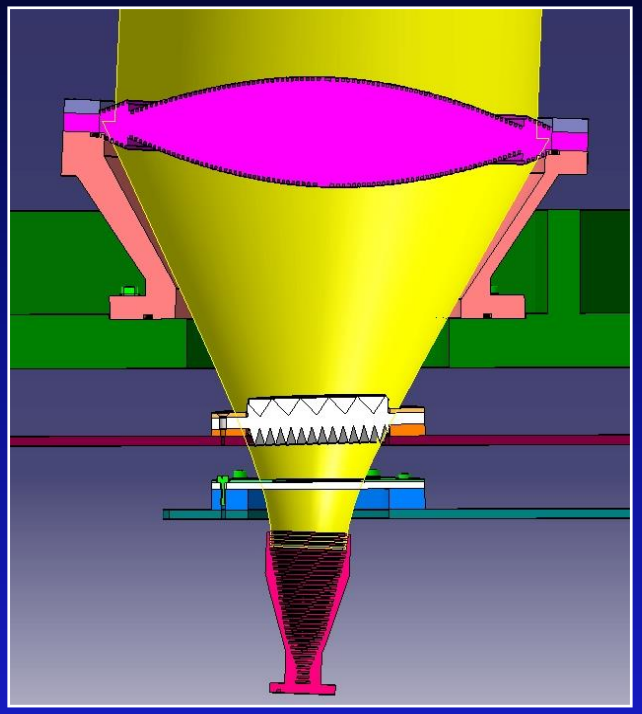


⇨ The Universe is expanding with acceleration.

Requires of a new form of energy.

Fundamental question: Which is the nature of dark energy?

6. The Astronomical Instrumentation

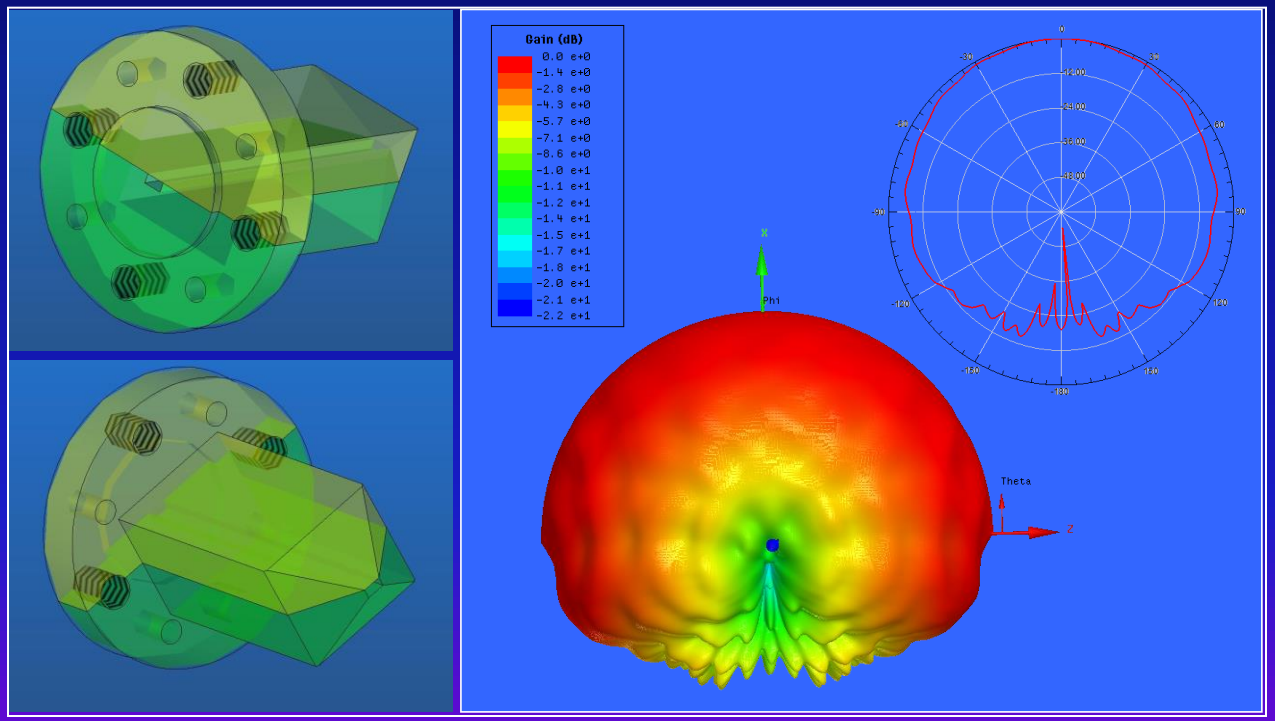


- Joint effort of Astronomy and Electrical Engineering
- Development of Front-End and Digital Back-end Technology
- Training of under and graduate students (PhD program)

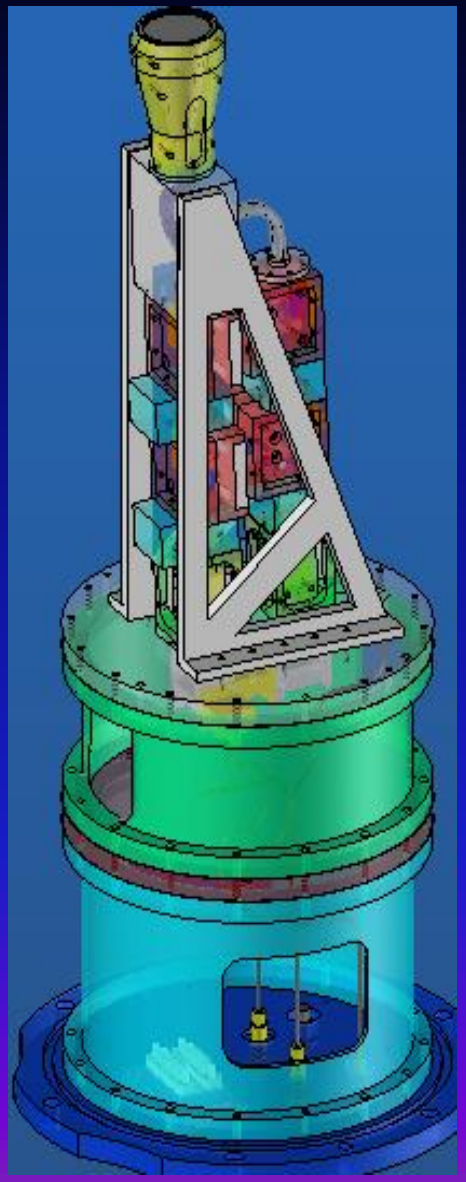
What we do:

Design → Simulation → Fabrication

Of components and complete radio-astronomy receivers in millimeter and submillimeter wavelengths.

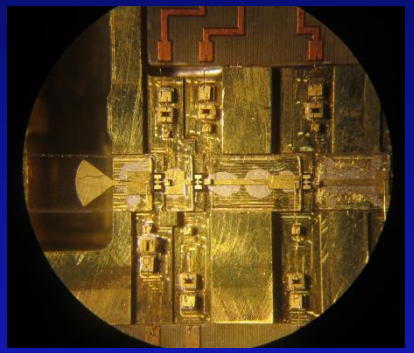


ALMA Band 1 (35-52 GHz) Receiver Cartridge

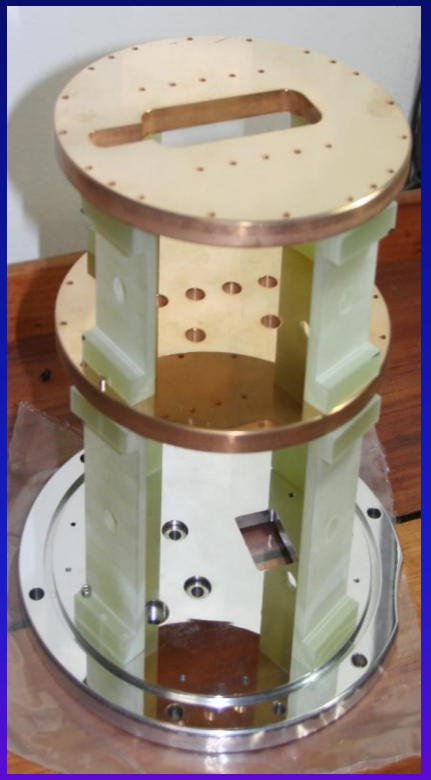


- We designed and built a prototype.
- Most components were built in our laboratory, some in collaboration with local industry
- +70 receivers will be built by a consortium including Taiwan, Canada, USA. **Chile's Work Package phase 2: Optics.**

Ortho Mode Transducer



Low Noise Amplifier



Support structure built in collaboration with local industry.

Waveguide filter

Spline-profile corrugated Horn antenna

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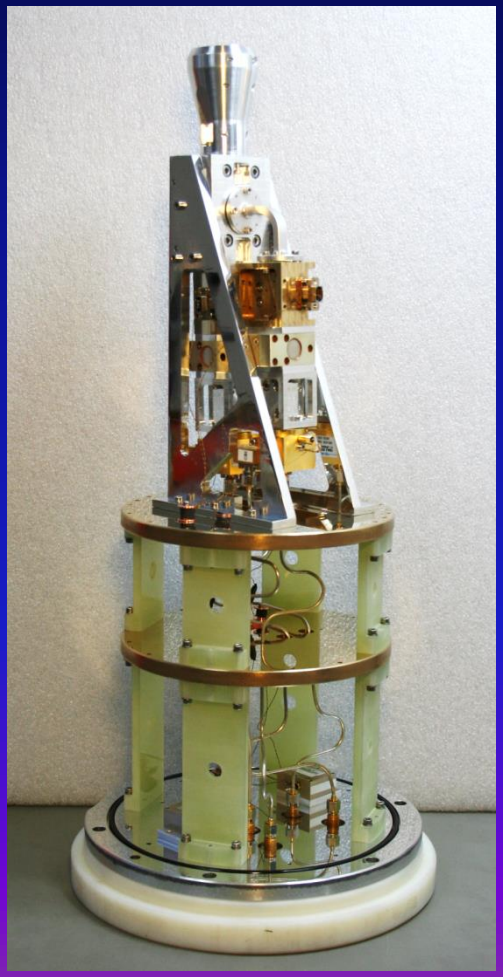
ALMA Band 1 View

Including the HDPE corrugated lens



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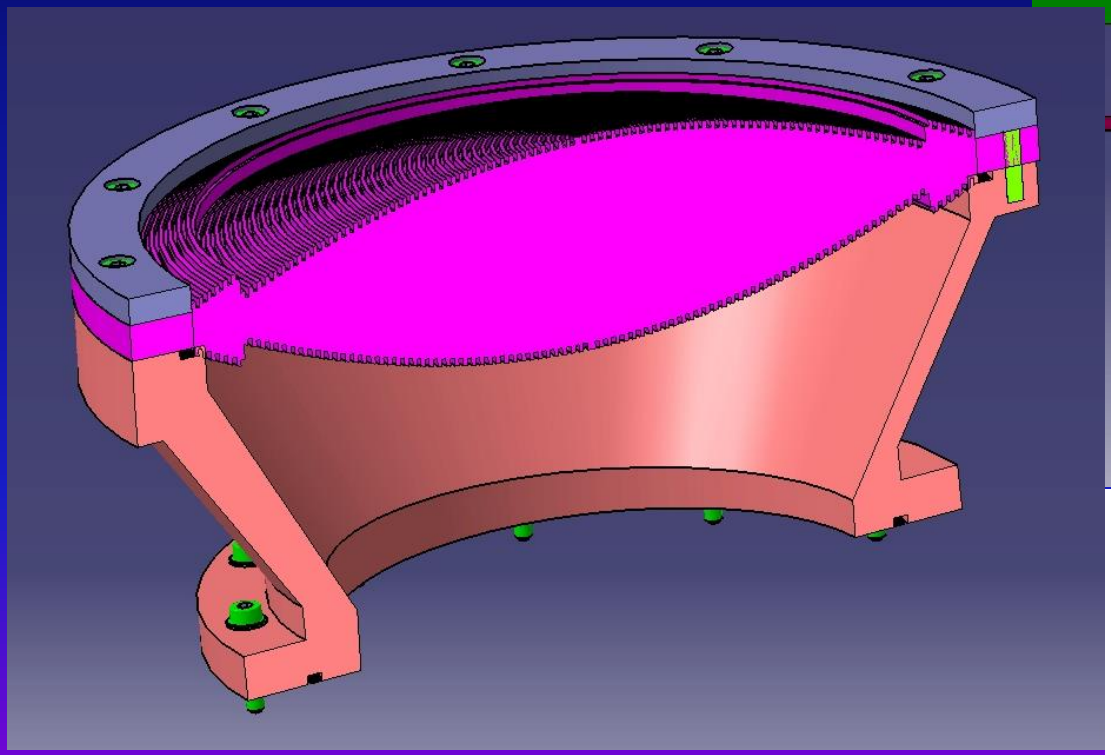
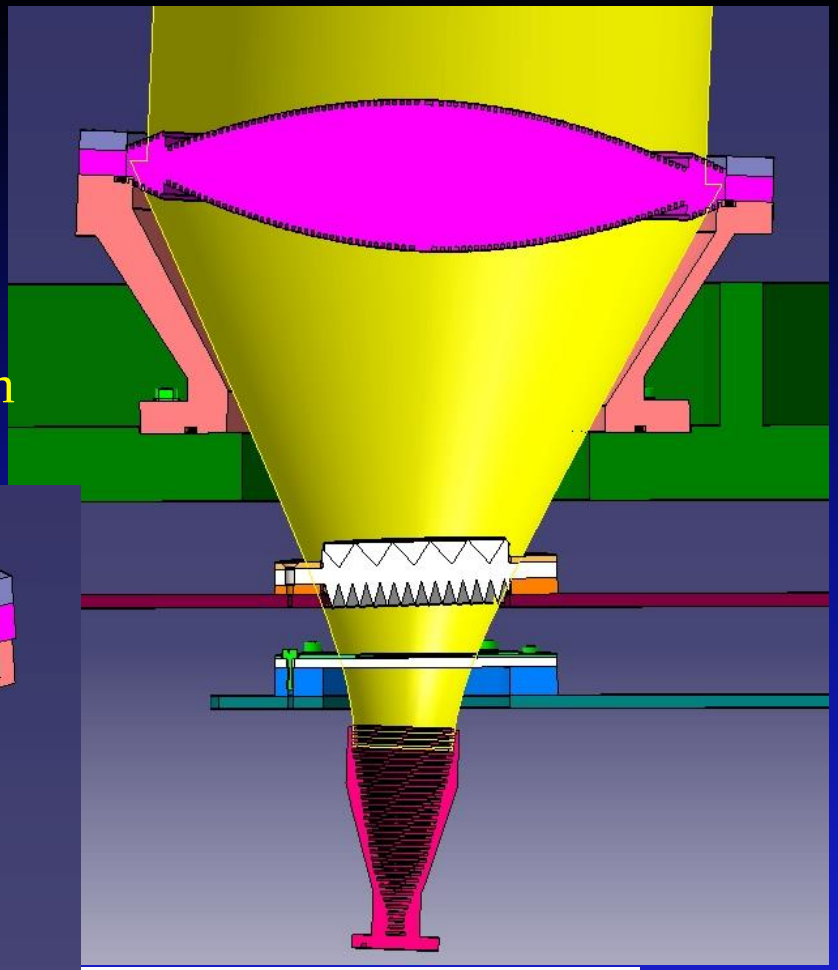
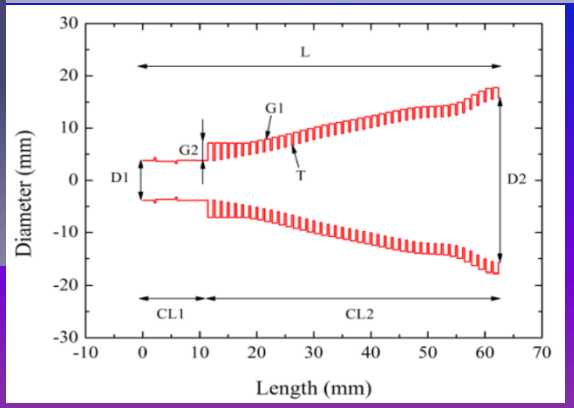
ALMA Band 1: Optics Work Package

- Corrugated Spline Horn
- Infrared Filters
- Bi-hyperbolic, Fresnel, corrugated vacuum lens







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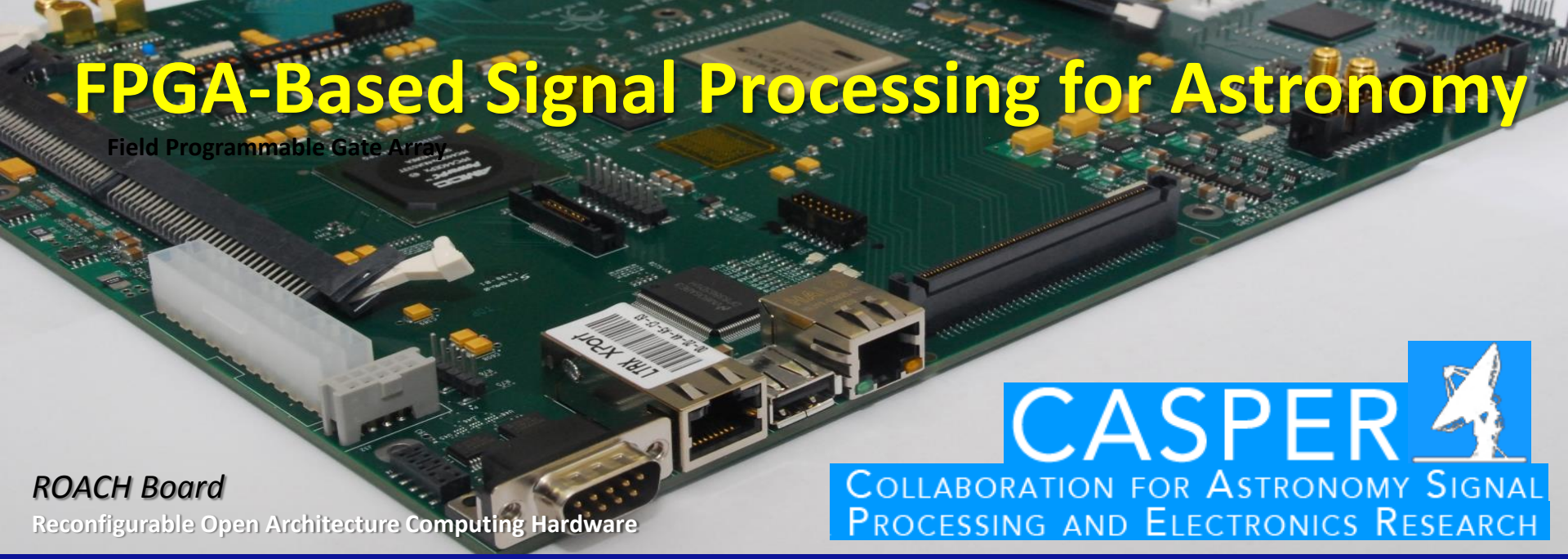
FPGA-Based Signal Processing for Astronomy

Field Programmable Gate Array



ROACH Board

Reconfigurable Open Architecture Computing Hardware

CASPER

COLLABORATION FOR ASTRONOMY SIGNAL PROCESSING AND ELECTRONICS RESEARCH

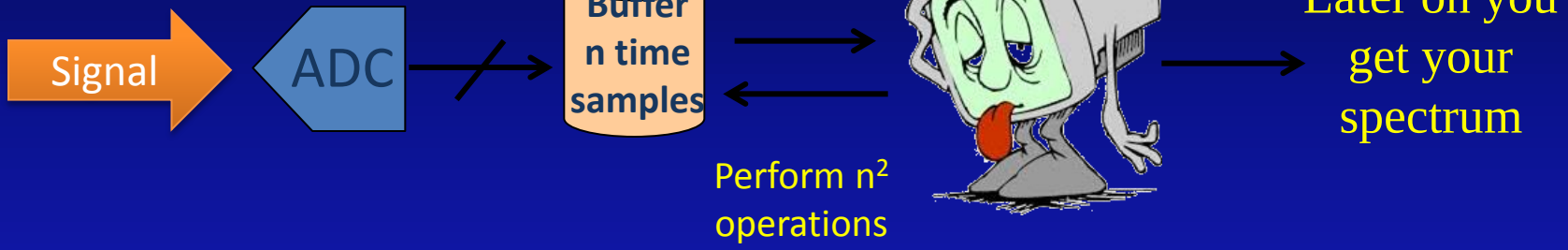
- We research novel ways to process astronomical signals by digital means.
- First results were published in 2013 and 2014 (two ISI papers).
- **New collaborations were opened as a results of this work:**
  - **Invitation to test this technology in SRON (Netherlands) (July 2014)**
  - **An interships of a CAS (China) PhD student is planned to start in 2014**
- Possible applications to other areas of engineering, like robotics, artificial vision, medical/security imaging, aerospace and defense.

FPGA application Example:

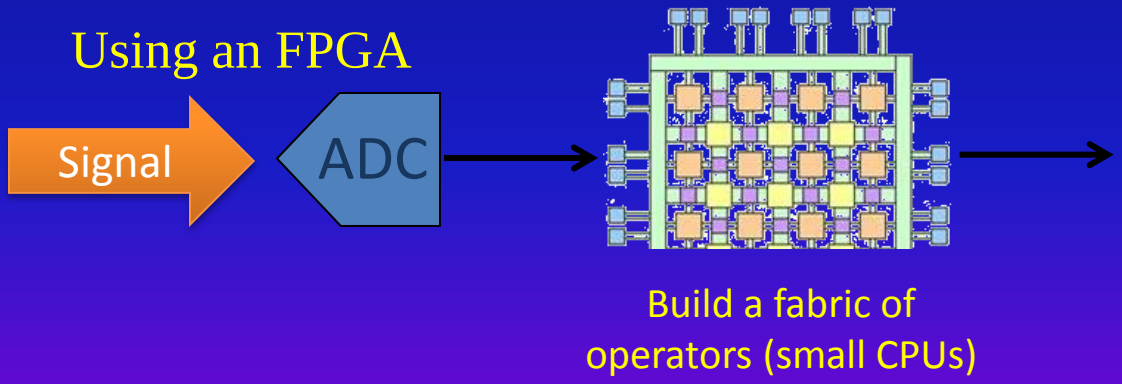
The Fourier transform is a n^2 algorithm.

$$V_s = \frac{1}{\sqrt{n}} \sum_{r=1}^{n} u_r e^{2 \cdot i \cdot r \cdot 1 \cdot s \cdot 1 \cdot n}$$

Using a normal computer

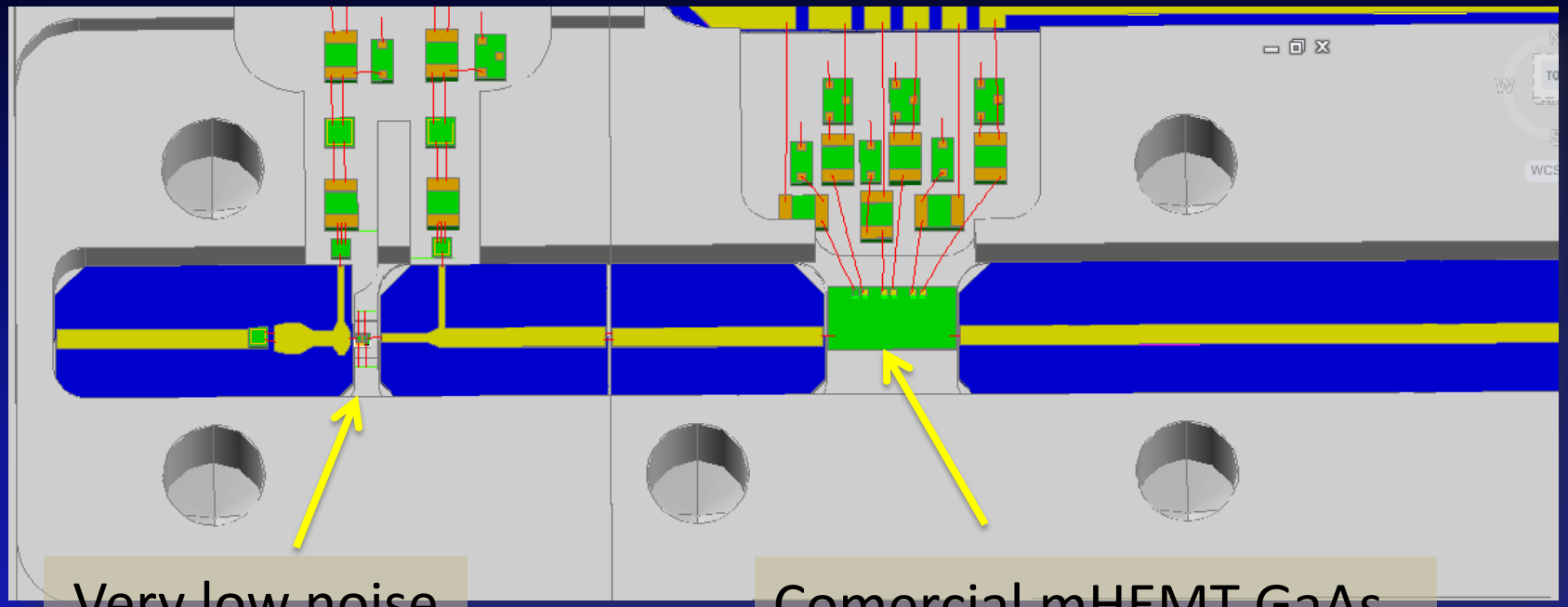


Using an FPGA



Truly parallel computing !! (in hardware)

Hybrid LNA Development



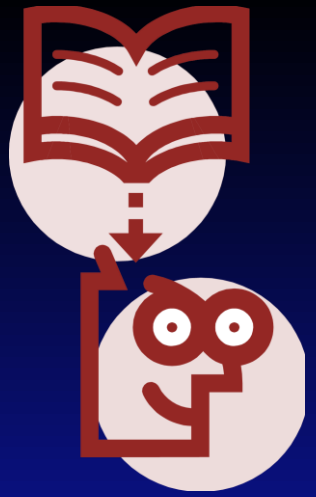
Very low noise InP Transistor

Comercial mHEMT GaAs MMIC

Pros:

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.

Summary



- We are living an exciting time in Astrophysics, with many open and new questions
- Chile has consolidated as the main hub of major astronomical facilities to tackle these questions
- Astronomical community has grown accordingly in the country covering all major areas of research
- A more recent astronomical instrumentation effort is under development to contribute with new state of the art instruments
- International collaborations both in science and technology are central to our development plan, so we are very open for collaboration !

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http://www.das.uchile.cl/lab_mwl/

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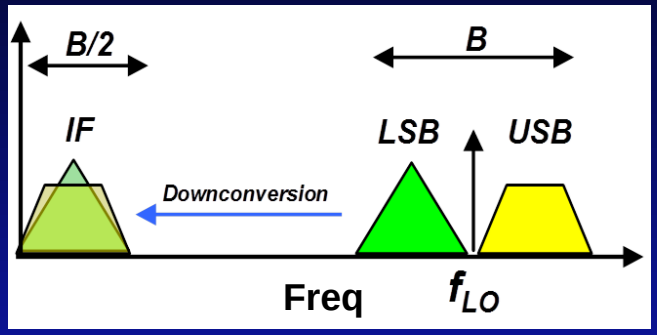
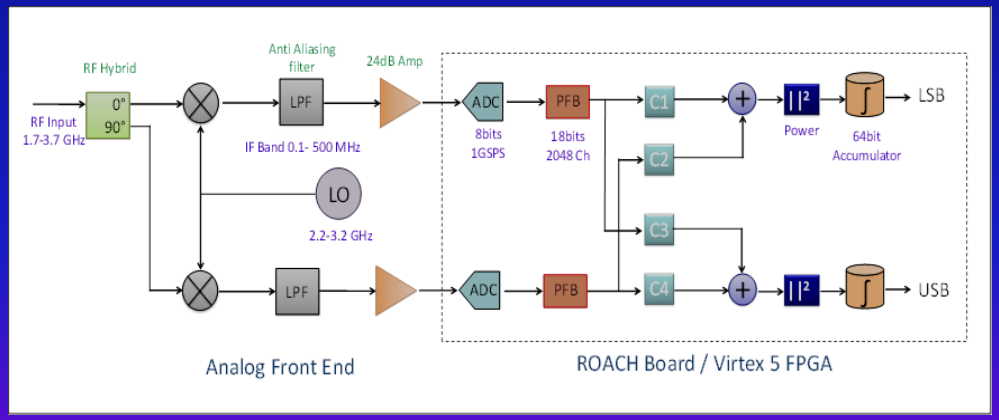
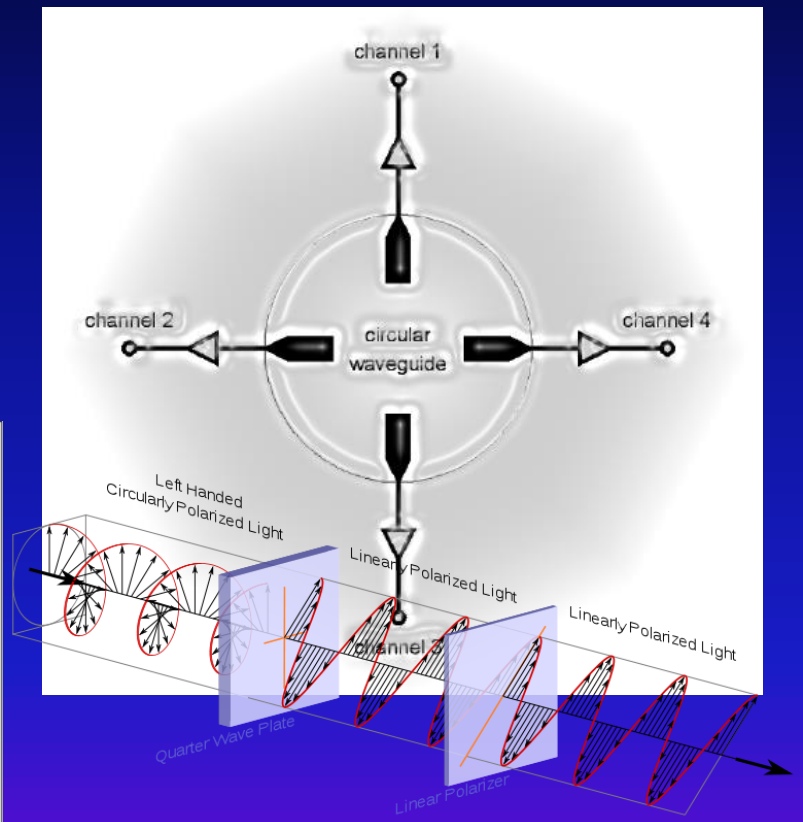
http://www.das.uchile.cl/lab_mwl/

FPGA-based Signal processing for astronomy Main Applications



Frequency mixing process. After downconversion the USB and LSB are overlapped an the IF band.





Digital Sideband Separation

Digital Polarization Detection