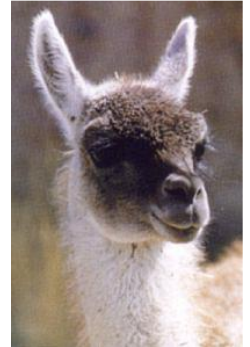


THE ORIGIN OF PROJECT LLAMA

“LARGE LATIN-AMERICAN MILLIMETER ARRAY”

Félix Mirabel (IAFE-CONICET)



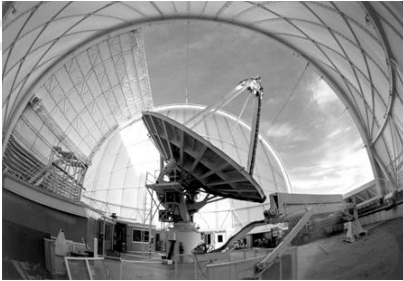
- **The early scientific motivation of project LLAMA** based on my experience in the incipient millimeter radio astronomy in the areas of extragalactic and high energy astrophysics in the years 1980 to 2000. In this meeting will be shown that the present scientific motivations for LLAMA concern almost all areas of astrophysics.
- **The early search of sites** for sub-millimeter astronomy in the Puna (NW of Argentina)
- **The Latin-American international context** when project LLAMA was first proposed
- **The interdisciplinary motivations** for LLAMA

Macon

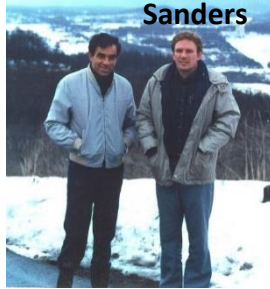
EXTRAGALACTIC ASTRONOMY WITH LLAMA: LUMINOUS INFRARED GALAXIES (« LIRGs »)

- **The discovery (1980-1985):** « **Bright Radio Spiral Galaxies** » with extended bright radio continuum emission observed with the VLA and deep turbulent absorption in the 21cm of HI (Arecibo)
- A proposal for $^{12}\text{CO}(1-0)$ observations at mm waves is submitted

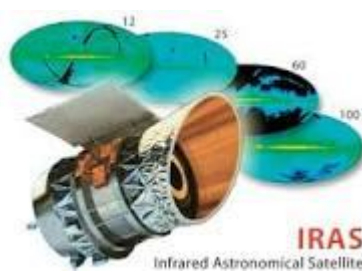
12m NRAO at Kit Peak



In Nobeyama
Sanders



IRAS satellite



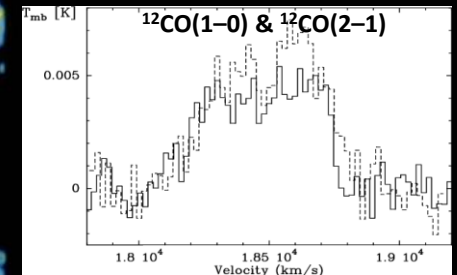
The Superantennae

$V = 18.500 \text{ km/s}$
 $d = 250 \text{ Mpc}$

10 kpc

ULIRGs: $L_{\text{ir}} > 10^{12} L_{\odot}$ and $M(\text{H}_2) > 10^{10} M_{\odot}$ →

- That L_{ir} comes from dust heated by super starbursts & SMBHs. The IR emission at high z arrives to us at sub-mm wavelengths.
- By observation of high level transitions of ^{12}CO and the [CII] line at $158 \mu\text{m}$, large populations of galaxies with properties similar to ULIRGs are detected by ALMA up to $z=7$ and JWST up to $z=14$.

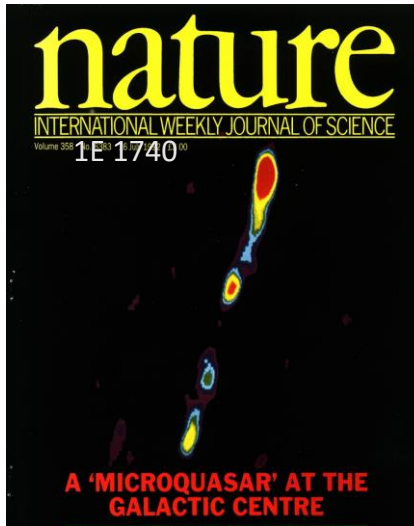


Could LLAMA surveys of high z galaxy clusters reveal even larger populations of ULIRGs?

HIGH ENERGY ASTROPHYSICS WITH LLAMA: MICROQUASAR RELATIVISTIC JETS

1994

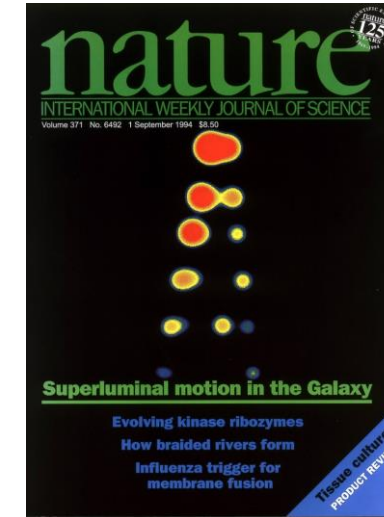
1992



L.F. Rodriguez



GRS 1915



Because of the relative small time scales of the phenomenology in microquasars, observations in the mm regime with simultaneous X-rays, IR and radio observations are possible, which helps to understand the emission mechanism in relativistic jets.

**LLAMA in multiwavelength campaigns of microquasars
may be important for the physics insight on relativistic jets**

Early search of sites for sub-millimeter astronomy in the Puna

- In 1984 is initiated the search of a site in the Puna for the European project “LSA” : Collecting area of 10^3 m^2 by 50 antennae of 16m diameter at 3500-4000m of altitude for observations at 350 GHz with a resolution of 0.1”.



- But LSA (Europe), MMA(USA), LMA (Japan), merge in project ALMA in Chajnantor for scientific & political reasons
- **ALMA**: 66 antennae a 5050m with a maximum baseline of 14km to operate at 3.6-0.32 millimeters
- **2004-2009**: As director of ESO in Chile I realize the importance of APEX (Atacama Pathfinder Experiment)



In 2008 the over subscription of time for APEX is about that for the VLT !

FIRST STEPS OF THE LLAMA PROPOSAL

- **2006-2009:** The idea of LLAMA is presented to: de Graauw (Director of ALMA), Charreaux (President of CONICET), Barañao (head of MinCyT) and Brazilian colleagues Jacques Lepine, Zulema Abraham, and Bete Gouveira Dal Pino.
- The first studies of the atmospheric conditions in Macón, and later in Chorrillos are managed by IAR (Ricardo Morras & Marcelo Arnal), with instrumentation (tipper) lend by UNAM, México thanks to L.F. Rodríguez and S. Lizano.

A WINDOW OF OPPORTUNITY FOR SOUTH AMERICAN ASTRONOMY

Journal at the General Assembly of the IAU in Rio de Janeiro (2008)

The possibility of installing two radio telescopes for millimeter and sub-millimeter wavelengths, in the Argentinean side of the Atacama desert at distances of 180-210 km from Chajnantor (the site of ALMA), and altitudes greater than 4700 meters, has been discussed among astronomers of Argentina and Brazil.

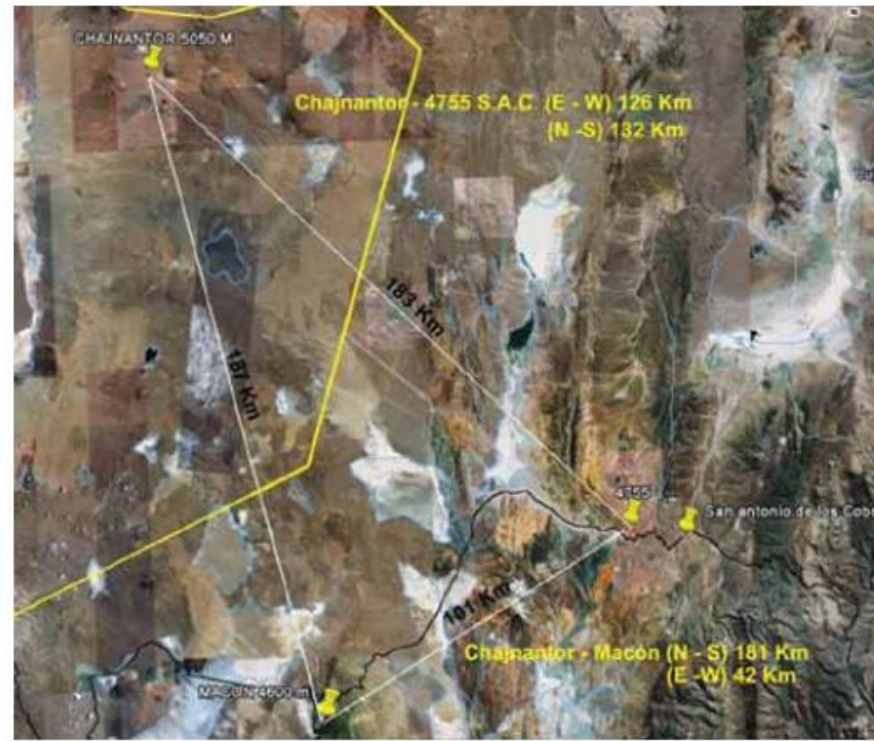
The support to this idea has been ratified in September 2008 by the Argentinean Astronomical Assembly. In Brazil it is being studied as one of the possible key science goals of the recently approved Astrophysics National Science Institute by the Brazilian National Council of Research - CNPq. Top authorities of Science and Technology in Argentina informed that in the context of regional integration, funds may be available for original projects on basic sciences, with technology transfer components.

The initial US\$ 20 million investment of LLAMA would allow Argentine and Brazilian scientists to develop millimeter and sub-millimeter single dish ra-

dio astronomy, as well as integration in global experiments with Very Long Baseline Interferometer networks. Of particular interest may be VLBI with already existing radio telescopes in Chajnantor (APEX and ASTE), and in the long run with elements of the ALMA array. Site testing in Argentina has been carried out for three years in Macón (4600m, 180km SE of ALMA) with equipment provided by UNAM (México), and further site testing started at other site 180 km SE of Chajnantor (see attached map). A proposal for initial funding to carry on the in depth study of this project will be submitted by December 2009.

We invite you for an open meeting on this project that will take place on Tuesday August 11 at 17:30 in room 2.11.

I.F. MIRABEL, M. ARNAL,
R. MORRAS, G. ROMERO,
J. LEPINE, Z. ABRAHAM,
EL. M. DE GOUVEIRA DAL PINO



LOCATION OF CHAJNANTOR, MACÓN AND CHORRILLOS. THE YELLOW LINE SHOWS THE BORDER BETWEEN ARGENTINA AND CHILE, THE BLACK LINE THE RAILWAY TRACK SALTA-ANTOFAGASTA.

- MinCyT establishes that IAR will manage project LLAMA in collaboration with the University of Sao Paulo (FAPESP).

General motivations of LLAMA

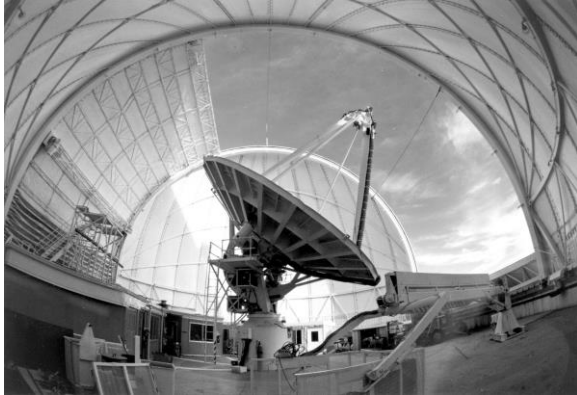
- Integrate the Latin American Astronomers to the frontier of research with ALMA and the Event Horizon Telescope.
- A ~US\$ 20 million investment would allow integration in a global project that entails an investment of >US\$ 1.4 billion.
- It is an original, scientific & technological project. It would not compete with goals already achieved (e.g. optical and near IR telescopes installed in Chile decades ago).
- It would serve as testing ground to correct regional scientific-technological integrations, step by step, and in progressive way, since in the long run, this project may require the installation of antennae in several countries of the region.
- LLAMA is an ideal context to train human resources in material engineering and microwave technologies, which has applications in telecommunications, surveys of natural resources, microelectronics, national & international science management.

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Reseñas de la Asociación Argentina para el Progreso de las Ciencias.

RADIO TELESCOPIOS MILIMETRICOS

12m NRAO en Arizona (1984)



15m SEST in La Silla (1985)



12m APEX (Chajnantor 2005)



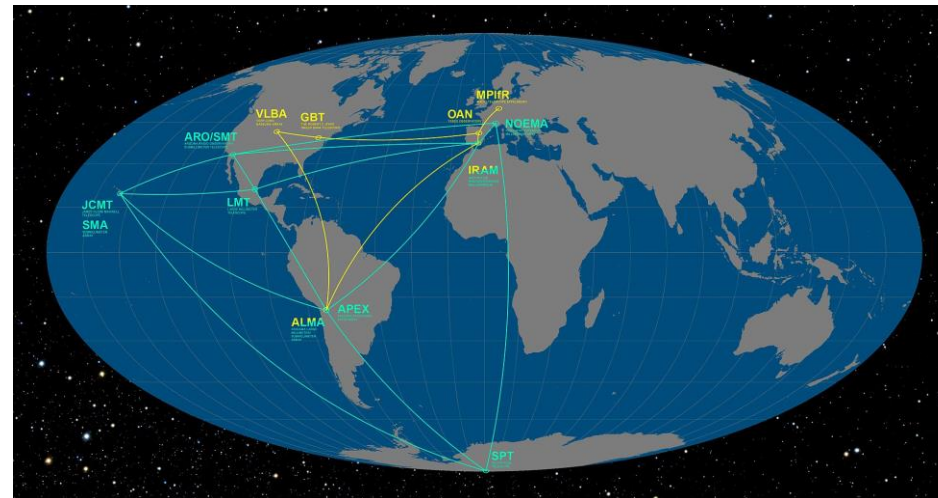
13.7m Itapetinga (~50 GHz)



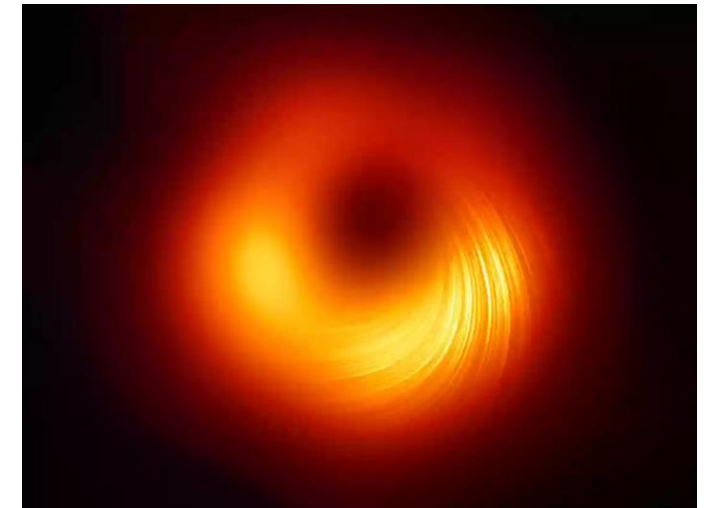
ALMA 66 antenas (0.32-3.6mm)



Event Horizon Telescope (1.3mm)



M87 (en luz polarizada $D=0.0013$ pc)



LLAMA en Alto Chorrillos



LLAMA en San Antonio



Salta: “Ventana al Universo”

SALTA: “LA LINDA”



SITUACION ACTUAL DE LLAMA

