ALMA Observatory
Status and new frontiers

Jorge Ibsen
Head of ALMA Department of Computing
Joint ALMA Observatory, Santiago de Chile, Chile

In search of our Cosmic Origins

ALMA: A worldwide operation

ARC NA
NRAO
ARC EU
ARC EA
NAOJ National Astronomical Observatory of Japan
ALMA CL
OSF/ AOS
SCO

KEYS

Astronomical Community

Data type

Scientific data

Scientific requests

1 Proposal submission

2 Observation planing

3 Scientific data flow (main archive)

4 Scientfic data distribution (ARCs)

5 Archive queries

ARC: ALMA Regional Center

International partnership

- International partnership among East Asia, Europe and North America in Chile. 20 countries involved
- Total Construction Cost ~USD 1.5 B
- Inaugurated in March 2013

- ~31 years from since initial idea
- ~21 years from site hunting
- ~11 years from starting

Joint ALMA Observatory

AOS
Antenas
Power
Fiber Optic Network
Local Oscilator (Timing)
Correlator

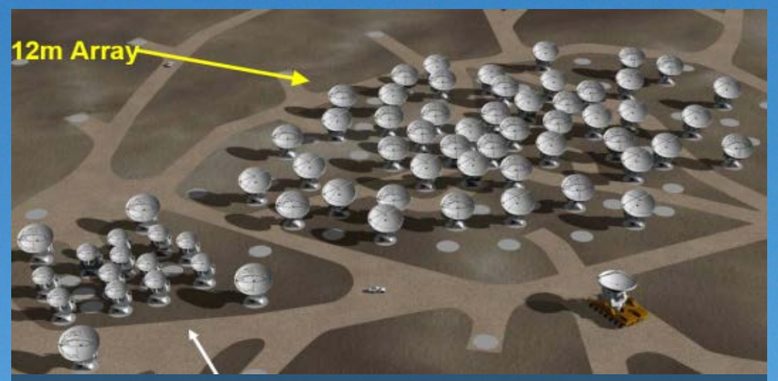
OSF
Hotel
Archive
Laboratoreo
Maintenance
Array Control Center
Integration Center

SCO
Main Archive
Data Transmmition
to the ALMA
Regional Center
Offices:
-Science
-Computing
-Administration
-Management

AOS as of May 13, 2014.
Photo courtesy of J. Guarda

What is ALMA?

The Atacama Large Millimeter/sub-millimeter Array (ALMA) is
array composed of **66 antennas,**
using ***aperture synthesis****, as a* “zoom telescope”
over the *entire accessible mm/submm* wavelength range



compact

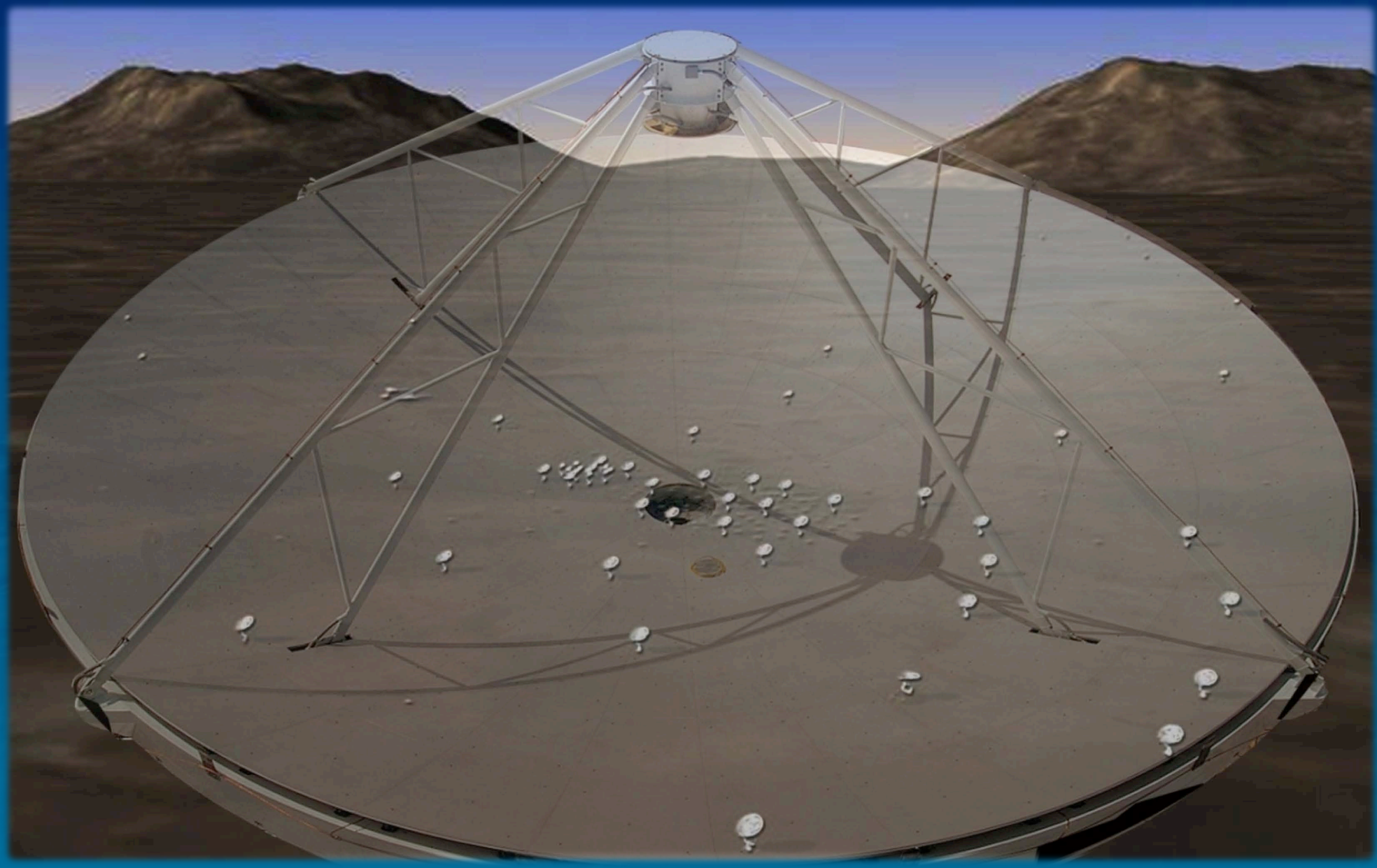
Built to operate

>30 yrs

extended

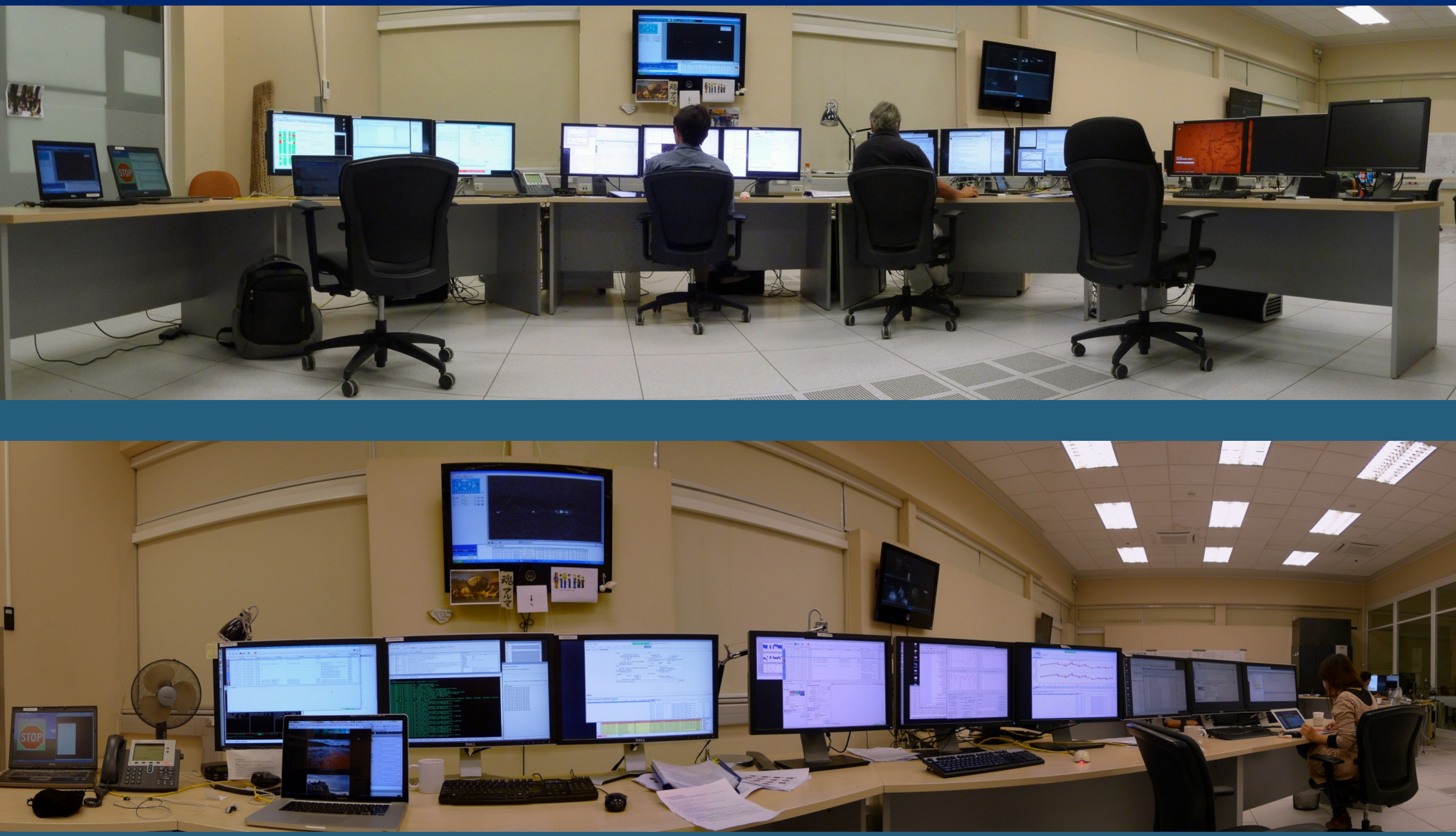
Remotely operated from
OSF Control room

Equivalent to a 16 km telescope



Aperture covered in time by:

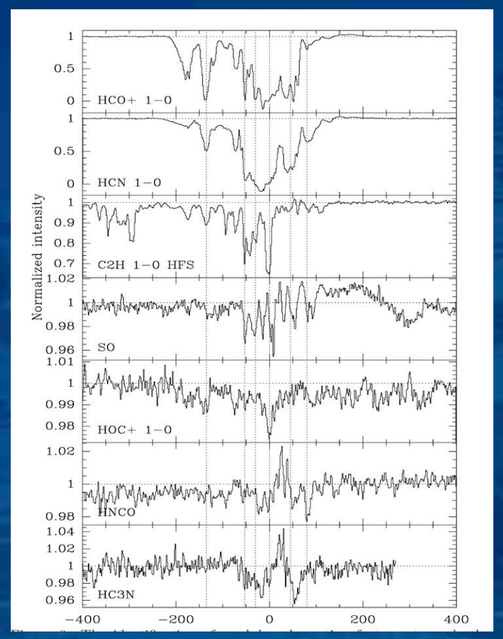
- moving the antennas to other foundations (there are 192 of them)
- Earth rotation



Control Room

Data Archive: about 750 GB/day

What brings ALMA to Science?



Angular Resolution

- ✧ better than Hubble ST in the visible
- ✧ ~10-100 times better than current mm interferometers

Spectral Resolution

- ✧ << 100m/s velocity resolution (radio technique!)

Sensitivity Speed

- ✧ large increase: 10 -100 times
  - 7000m^2 collecting area
  - State of the art receivers

Early Science: Cycle 0
March 30, 2011 – January 1, 2013

- Capabilities: 16 12-m antennas, receiver bands 3, 6, 7 & 9 (wavelengths of about 3, 1.3, 0.8 and 0.45 mm), baselines up to 250m, single field imaging, and a restricted set of spectral modes
- 919 Proposals: 113 High Priority projects, 51 fillers (500h)
- Proposal review committee: 50 people met in Santiago

Early Science: Cycle 1
May 31, 2012 – May 31, 2014

- Capabilities: 32 12-m antennas in the 12-m Array + 9 7-m antennas, and 2 12-m antennas for total power (single dish) observations, same receiver bands as in cycle 0, baselines ranging from 160 m to 1 km, single field imaging and mosaics of up to 150 pointings, and continuum and spectral line observations
- 1131 Proposals: 197 High Priority projects, 92 fillers (800h)
- Proposal Review Committee: 80 people met in Santiago

Early Science: Cycle 2
October 24, 2013 – September 30, 2015

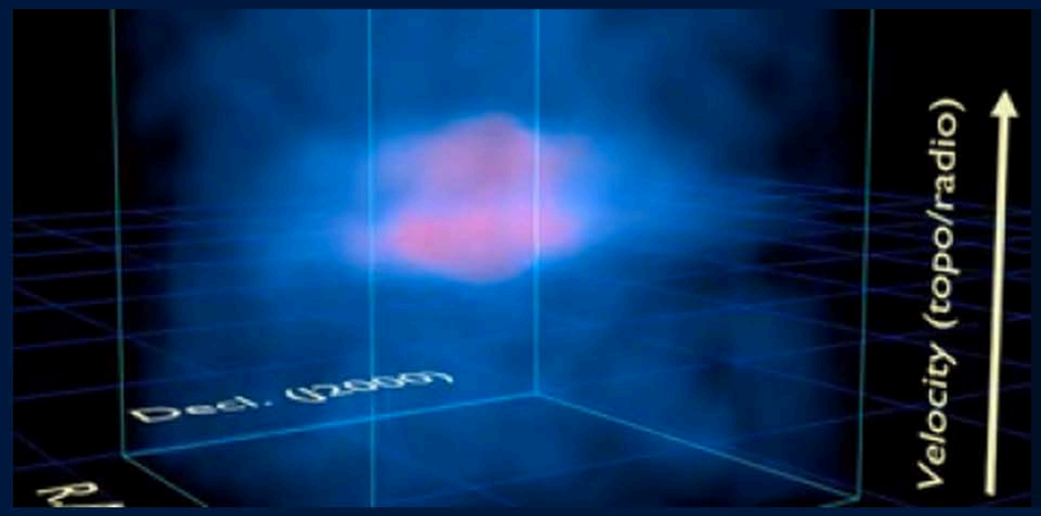
- ✧ Thirty-four 12-m antennas in the 12-m Array, nine 7-m antennas in the 7-m Array, and two 12-m antennas in the TP Array, Receiver bands 3, 4, 6, 7, 8 & 9 (wavelengths of about 3.1, 2.1, 1.3, 0.87, 0.74 and 0.44 mm)
- ✧ Both single field interferometry and mosaics, spectral-line observations with all Arrays (except Band 9 with the TP Array) and continuum observations with the 12-m Array and the 7-m Array, polarization (on-axis, continuum, selected frequencies in Band 3, 6 and 7, no ACA, no mosaics, no circular polarization), mixed correlator modes (both high and low frequency resolution in the same observation)
- ✧ Baselines up to 1 km for Bands 8 & 9, Baselines up to 1.5 km for Bands 3, 4, 6, & 7

1381 Proposals: 353 highest-priority projects

Science Results

- ✧ Transformational science started
- ✧ Increasing number of papers using ALMA data
- ✧ Frequent announcement of new discoveries available at the ALMA web site

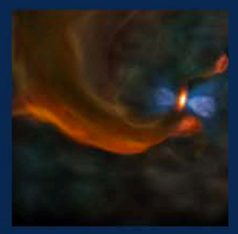
Press Releases



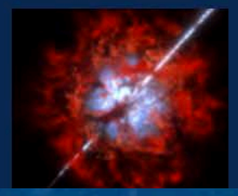
Thursday, 07 August 2014
ALMA Confirms Comets Forge Organic Molecules in Their Dusty Atmospheres

Tuesday, 05 August 2014
ALMA Pinpoints Pluto to Help Guide NASA's New Horizons Spacecraft

Wednesday, 30 July 2014
ALMA Finds Double Star with Weird and Wild Planet-forming Discs

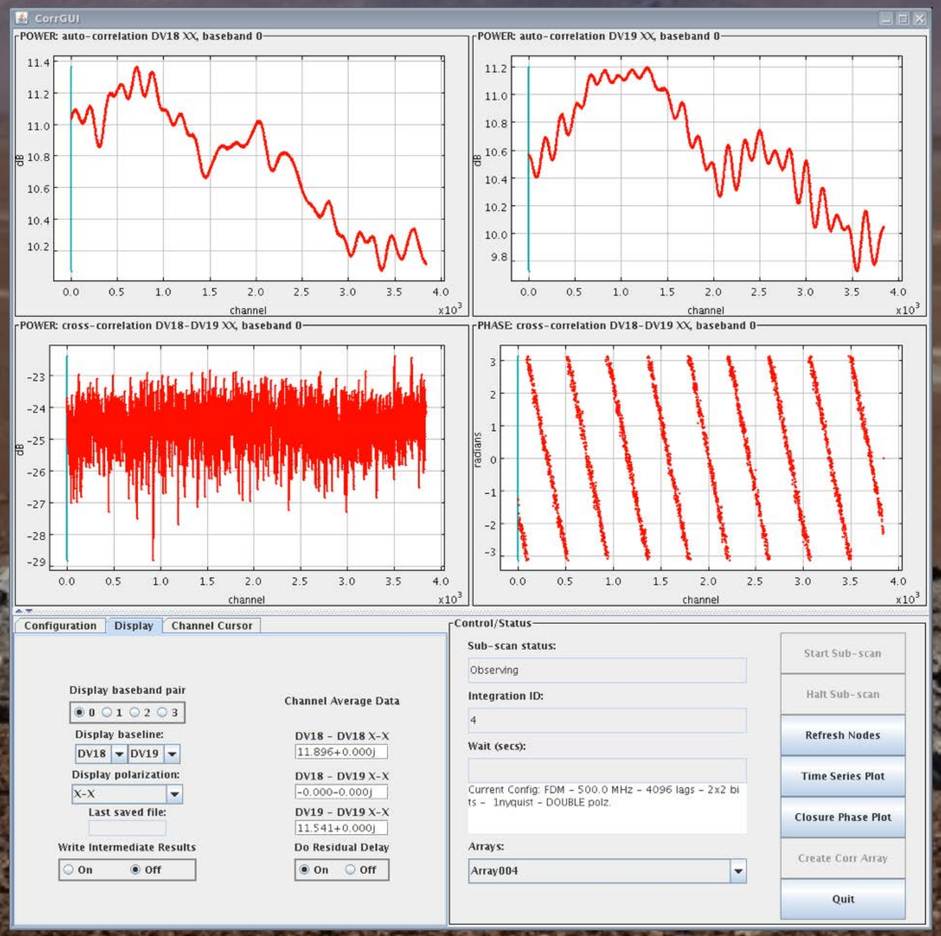


Thursday, 03 July 2014
Dynamical Star-Forming Gas Interaction Witnessed by ALMA



Wednesday, 11 June 2014
Gigantic Explosions Buried in Dust: ALMA Probes Environment around Gamma Ray Bursts

Visit http://www.almaobservatory.org/en/press-room/press-releases



First fringe on a baseline of 7.0425 km obtained on August 24, 2014 at 9:00 pm (CLT) at frequency 92.2 GHz with DV19 on pad P410

ALMA Development Projects for data

ALMA Data Mining Toolkit (ADMIT)

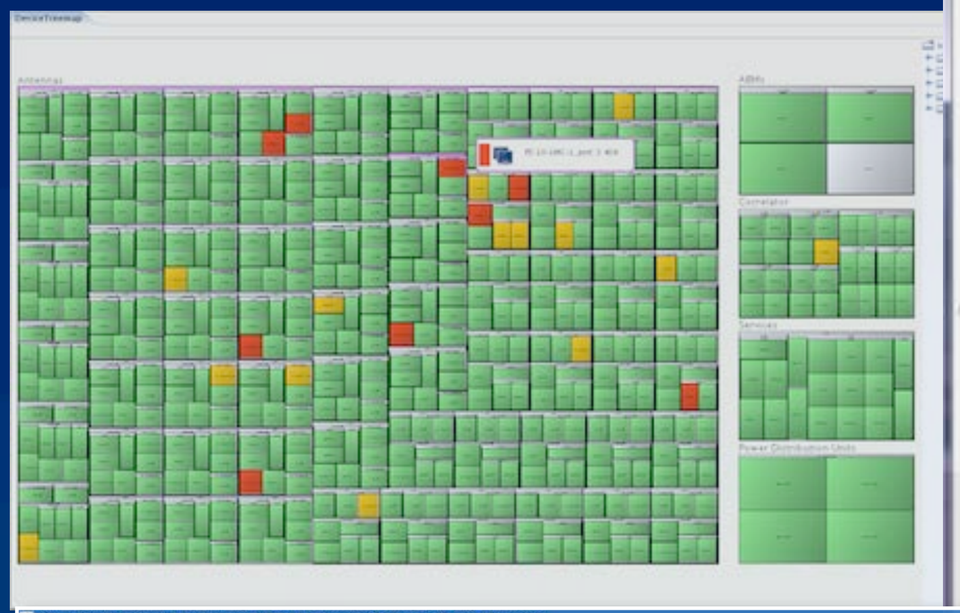
- Objective: To increase the scientific productivity of ALMA by creating a set of science-oriented data products and tools which enhance proposers' and archival data users' access to the science content in ALMA data cubes.

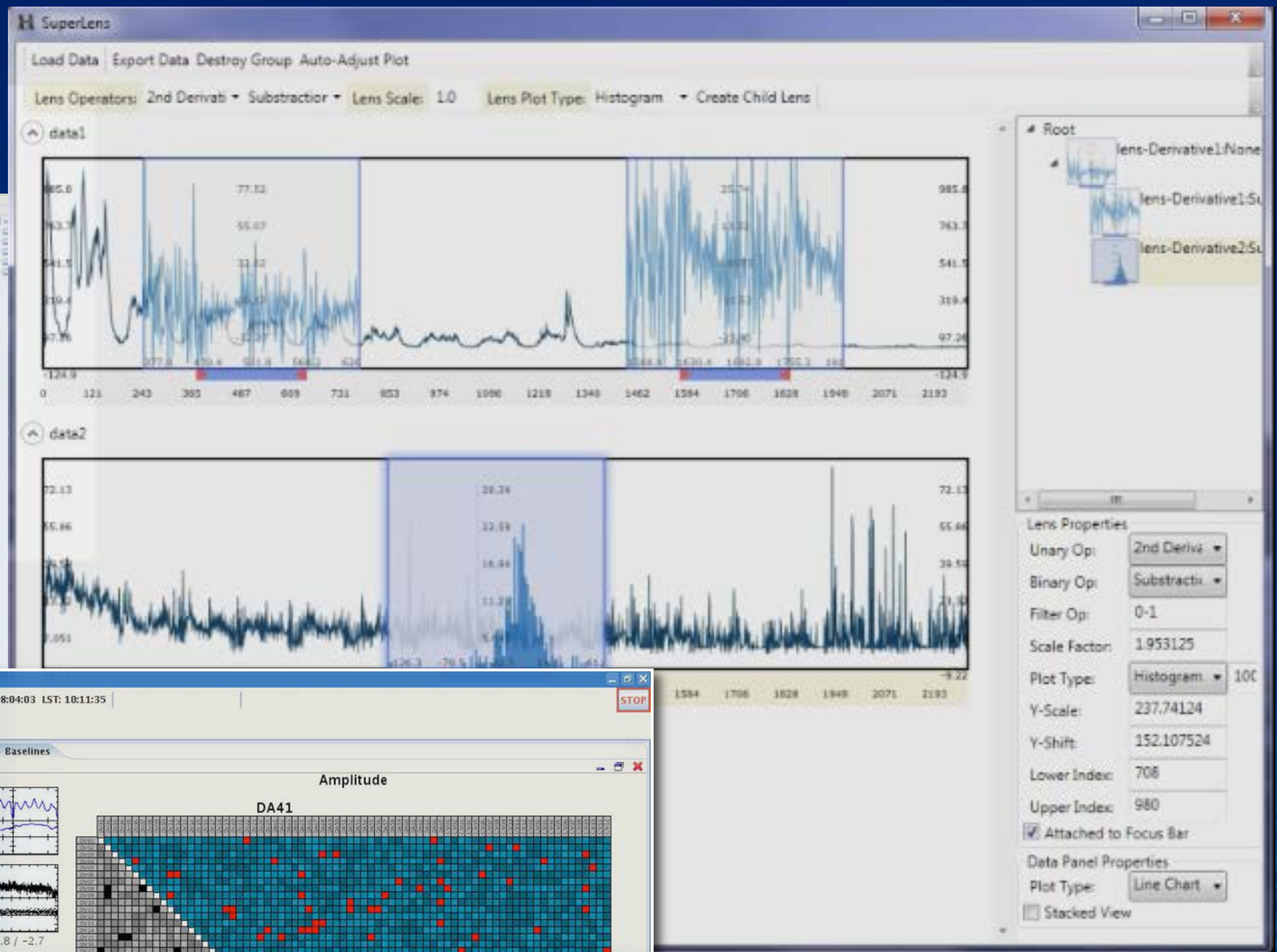
Cube Analysis and Rendering Tool for Astronomy (CARTA)

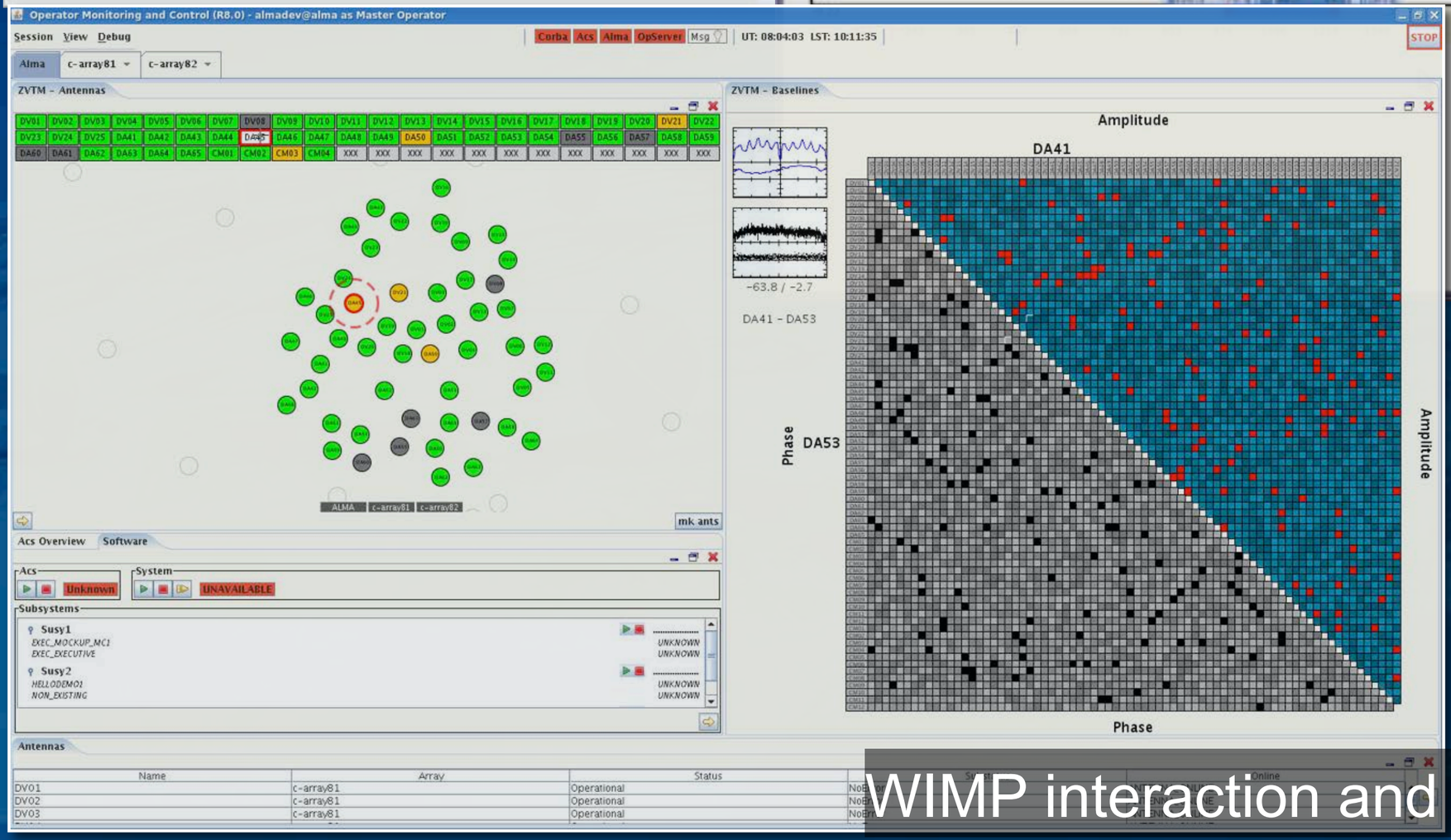
- Objective: Provide a next generation drop-in replacement for the current CASA viewer
  - Both local and remote visualization capabilities
  - Extensibility and maintainability
  - Enable Community Development

Collaborations: INRIA

Collaboration with Institute National de Recherche en Informatique et en Automatique (INRIA) started informally on May 2009. MoU signed in November 2011 with the objective of *both improving the efficiency and ease of use of ALMA and also of becoming a model state-of-the art development at a world class research facility*.







WIMP interaction and information visualization

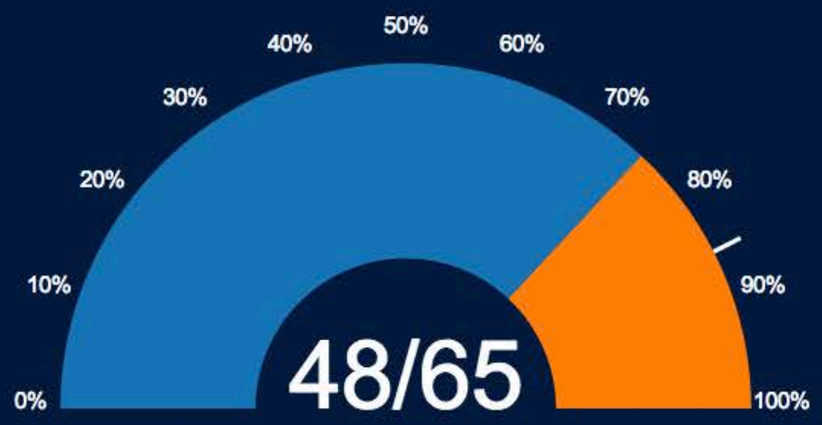
In search of our Cosmic Origins

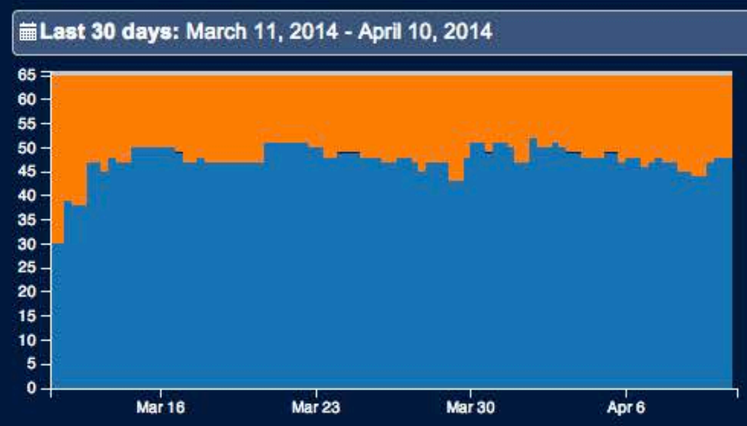
ALMA Dashboard

Overview | **Antennas** | Pads | Corr/CLO | Power | Logbook | Log in

Summary

	B3	B4	B5	B6	B7	B8	B9	B10
CM Antennas	6	1	0	6	9	1	5	0
Inner Array: Outer Ring	11	0	0	13	13	0	12	0
Southern Arm	0	0	0	0	0	0	0	0
DA+DV Antennas	25	1	0	27	26	1	26	0
Western Arm	0	0	0	0	0	0	0	0
Inner Array: Central Cluster	14	1	0	14	13	1	14	0
Pampa La Bola Arm	0	0	0	0	0	0	0	0
Total	32	2	0	35	37	2	32	0
PM Antennas	1	0	0	2	2	0	1	0
	B3	B4	B5	B6	B7	B8	B9	B10



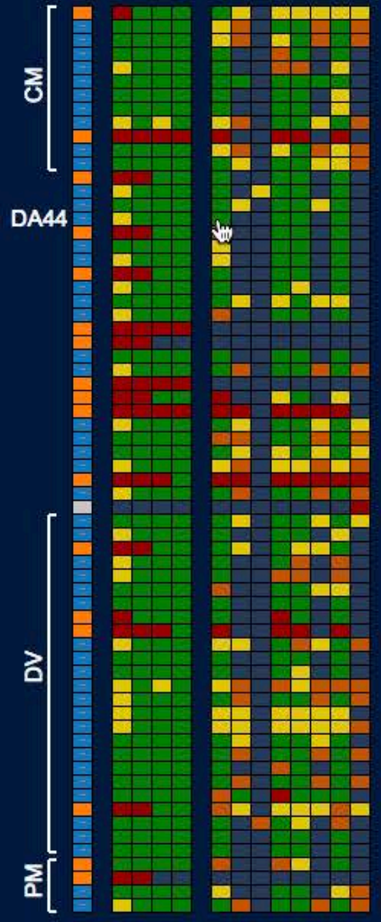


Array Elements

Full | Clear filters

Available | Not Available | O=Operational | C=Science | E=Engineering | S=Shutdown | Not Installed

Antenna	Pad	AE	AS	EE	ACD	B3	B4	B5	B6	B7	B8	B9	B10	BL	ACA		Search ADE...	Search CSV...	Search Remarks...
▲	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼	▲▼		▲▼	▲▼	▲▼



Current Status | Location | Timeline | Logbook

DA44

A068

Array Element | System | Equipment | ACD

B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10

Correlator Analog Input (CAI) Baseline: 29 ACA: NA

ADE (Main technical issues and comments): Clear Edit

PRTSIR-1894: AZ motor timeout disengaged (SOLVED temporarily... keep an eye) PRTSIR-46: AOS: DA44 mount can not initialized axis (Intermittent problem)
PRTSIR-1676: EL Encoder Head 1 fault (intermittent problem)

CSV (Status and Comments): Clear Edit

Remarks: Clear Edit

Membrane: GORETEX, Solar Filter: N/A

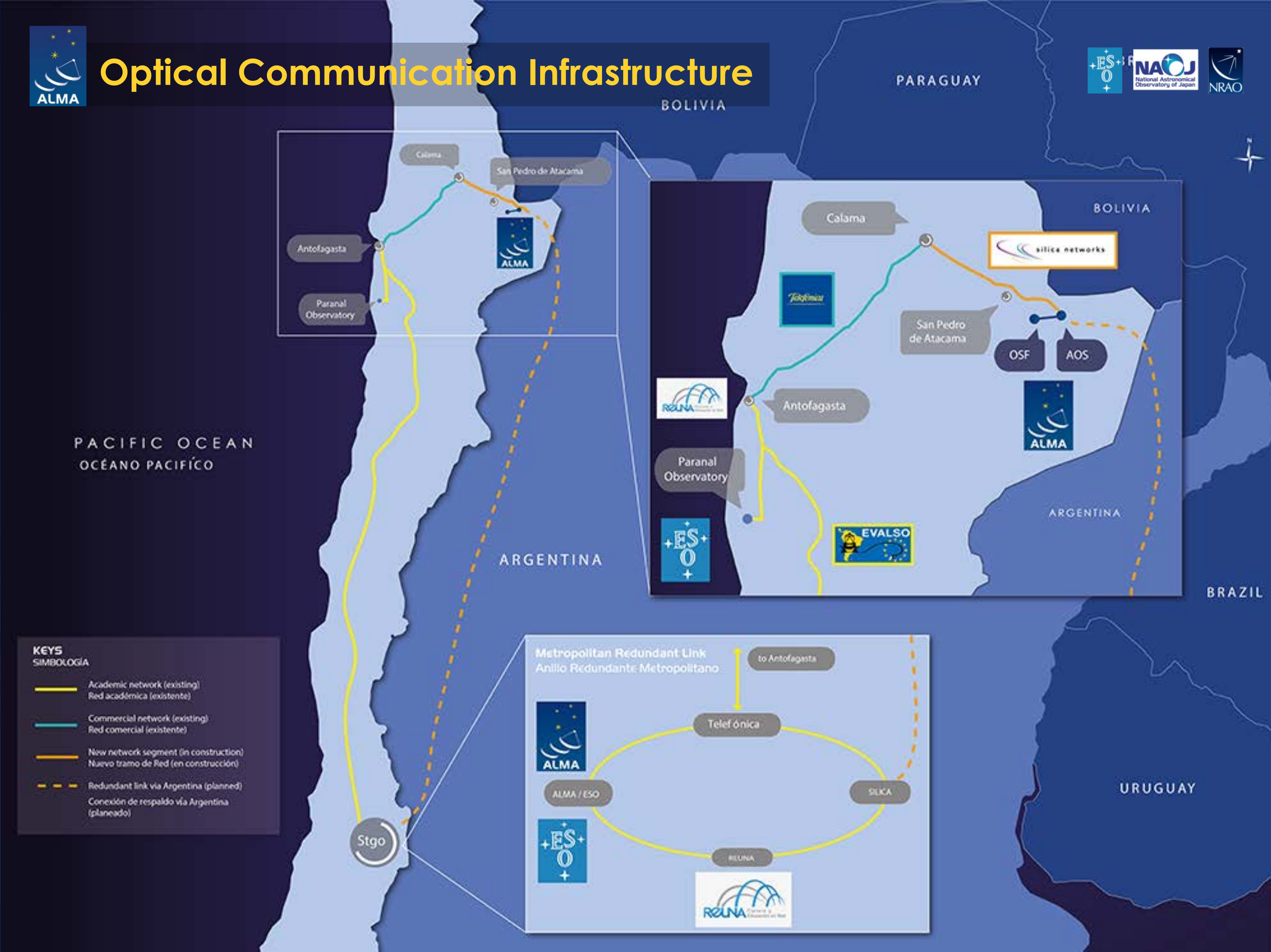
Save

Collaborations: REUNA

MoU signed in January 2012 with the purpose of

- ✧strongly supporting common efforts to operate and develop high bandwidth connectivity between the different ALMA sites.
- ✧providing the basis for a joint consideration of the support in connectivity needed by a possible Chilean centre for ALMA data archiving and high performance data reduction.
- ✧Encouraging informal information exchange and open to future collaborations and projects of mutual interest.

Optical Communication Infrastructure



Collaborations: FONDEF Project D11 | 1060

Development of an Astro-Informatic Platform for Management and Intelligent Analisys of Large-scale Data

- ✧ Main Objective: To develop a virtual observatory, semantic search algorithms on the data (labeled by astronomers), and integration of data mining techniques and artificial intelligence with HPC, allowing large-scale data processing in an efficient and effectively way
- ✧ Joint project between 5 major universities
- ✧ Sponsored by FONDEF, REUNA, and ALMA

Collaborations: National Laboratory for HPC

NLHPC is a consortia of seven universities and REUNA.

Mission

To consolidate a national facility for HPC by offering top quality services and advanced training to answer the national demand for scientific computing, developing links between research groups, the industry and the public sector.

Vision

Participants visualize the NLHPC as a highly competitive center with a range of research services in world-class-quality high performance computing.

MoU signed on January 13, 2014

Broader context
Observatories in Chile

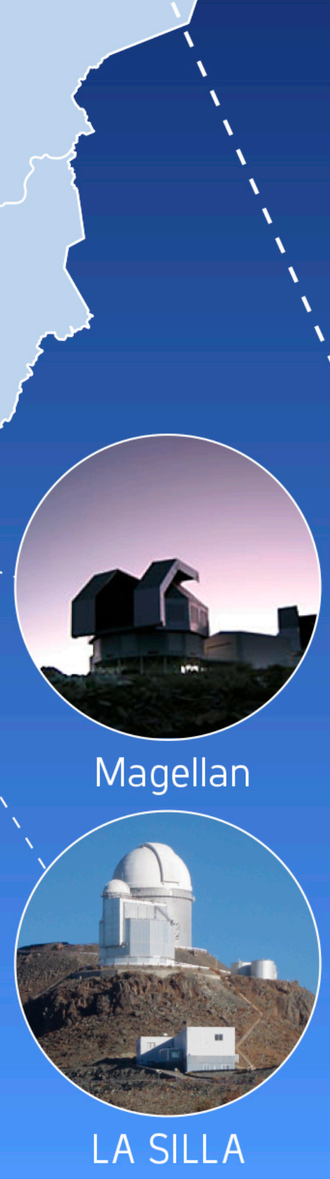
VLT

VISTA

GEMINI South

SOAR

TOLOLO



Magellan

LA SILLA

ALMA

APEX

ACT

ASTE

miniTAO

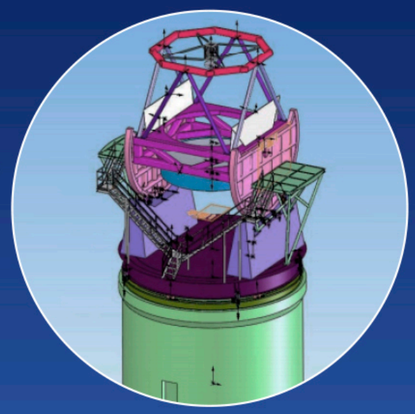
NANTEN2

POLAR BEAR

Broader context
Observatories in Chile (Future)

E-ELT

CCAT



TAO

LSST

GMT

Future challenges

- ✧ Produce world-class-top-quality-ready-to-use science data
- ✧ Continuous addition of capabilities through development programs
- ✧ 24/365 operations with high availability (95% in ALMA's case) while at the same time optimizing (i.e. reducing) operations costs

Requiring …

- Infrastructure development
  - Networks and data centers able to cope with transmission, storage and processing of massive data sets
- Research in Astronomy, Computing Science, and Engineering
  - Archive-based astronomical research
  - High volume data visualization and data mining
  - Human Computer Interaction
  - Network optimization for massive data transmission
  - Remote operations and virtual presence
  - Astronomical instrumentation

Thanks!

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.