



Atacama Large Millimeter/  
submillimeter Array - ALMA

# ALMA Status, Science Operation, and EA Science activities

Satoru Iguchi

ALMA - East Asian Project Manager

National Astronomical Observatory of Japan



# Status



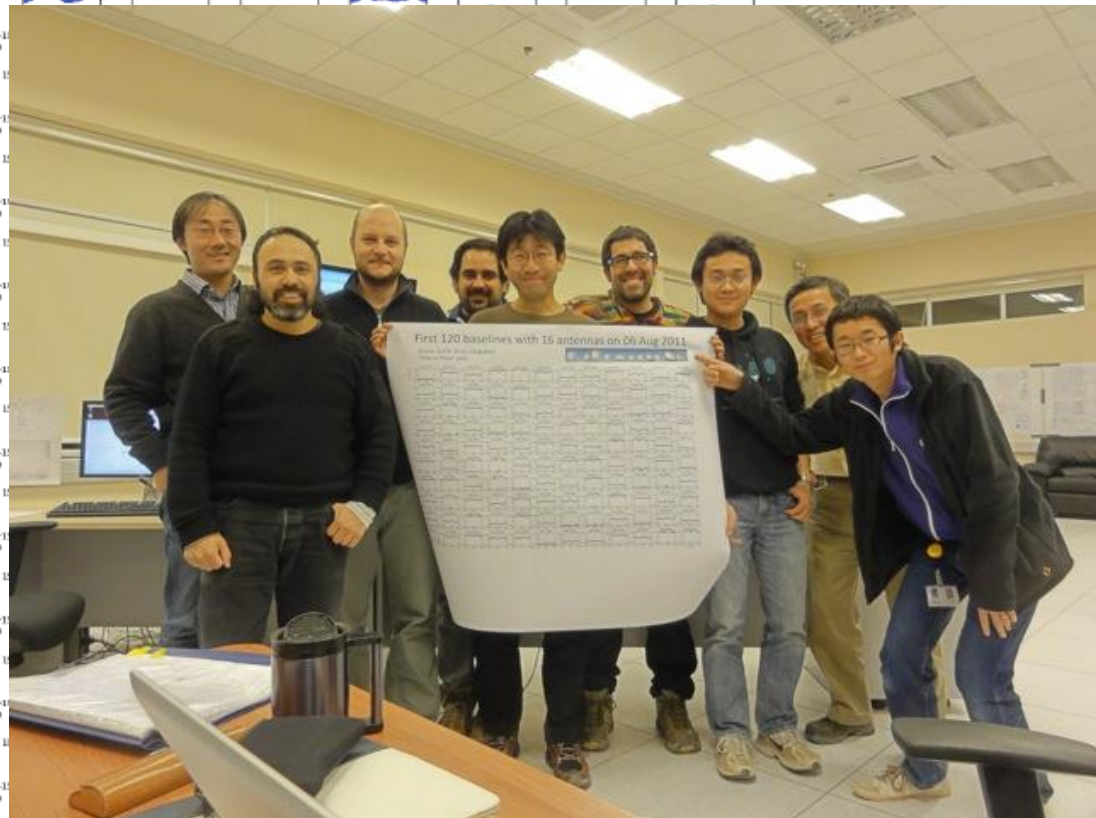
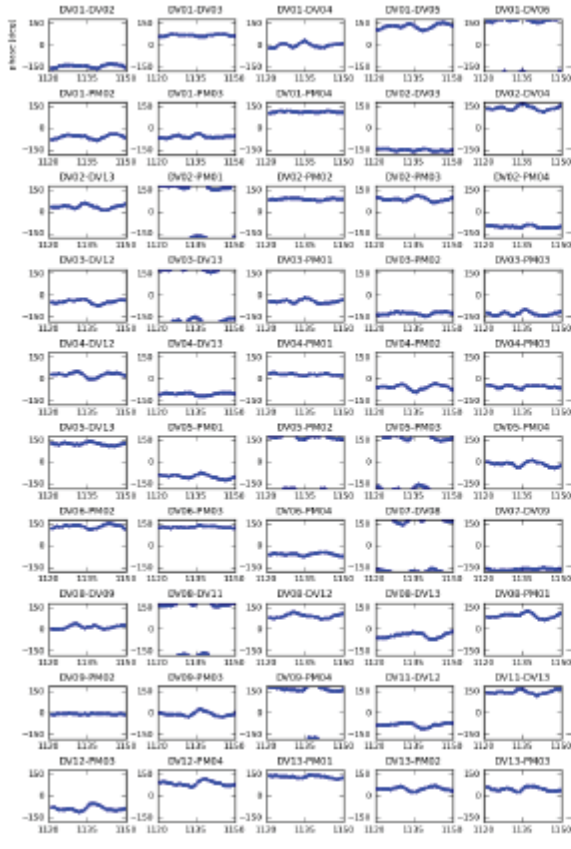
# Latest Status

- Array Operation Site (altitude 5000m)
  - 24 antennas on Nov 3, 2011 (see below 22 antennas)
  - ✓ EA: 8 (4x12m, 4x7m), EU:2, NA: 14



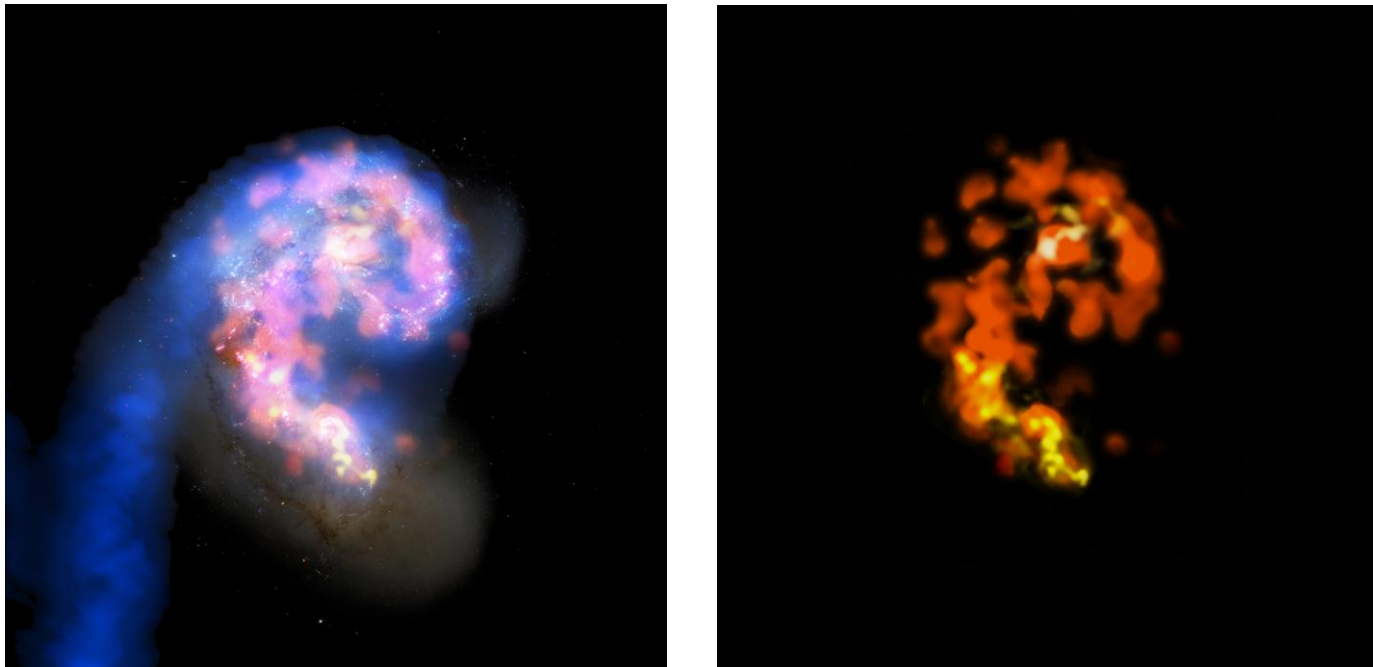
# Commissioning Science Verification

- 06 Aug, 2011: 120-Baseline Fringes with 16 antennas
  - 3C 279 (30-sec Integ.)



# Demonstration Science

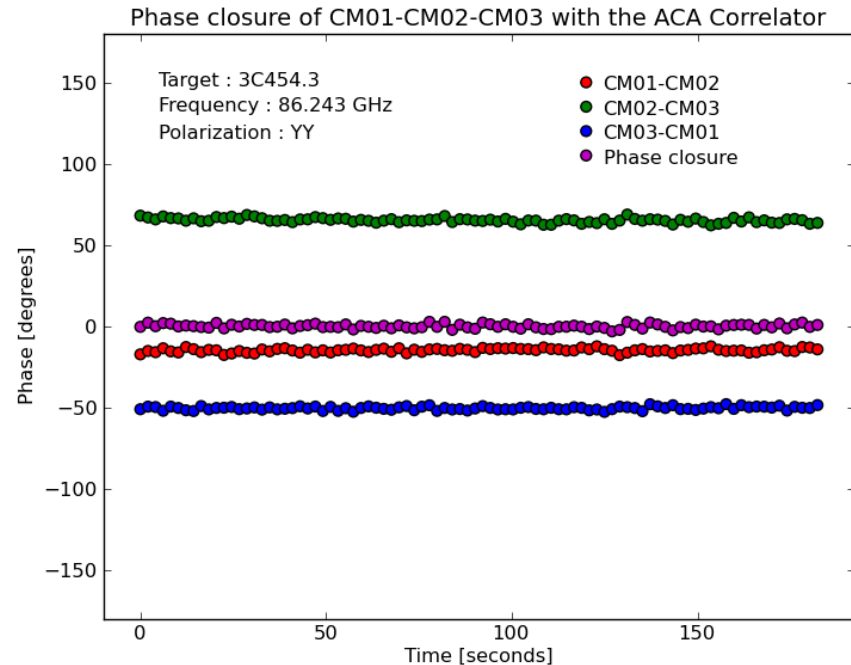
- Antennae Galaxies (NGC4038/4039)



- Orange ALMA (J=1-0 CO), Yellow ALMA (J=3-2 CO) with 12 ant.
- Blue VLA radio, Stars & H+ from Hubble & CTIO

# Commissioning Science Verification

- Status related to Japanese 7-m antennas
  - On **October 23**, an interferometer test was conducted using **three Japanese 7-m antennas and a Japanese correlator** installed at the Array Operations Site (AOS) at 5000 m asl, and interference fringes were successfully obtained.





# Science Operation



# Start Early Science Operation on September 30, 2011

NEWSFOCUS



ASTRONOMY

## First Global Telescope Opens An Eye on the Cold Universe

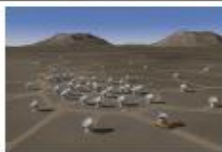
Within days, astronomers will start peering into the coldest corners of the cosmos using a partially completed array of antennas in the deserts of northern Chile.

When we look at the sky, most of what we see are objects that glow: hot stars, galaxies, supernovae, and the luminous gas clouds of star-forming regions. This month, astronomers will test-drive an instrument that will give them a new view of our familiar sky: the universe of cold things. The Atacama Large Millimeter/Submillimeter Array (ALMA) will focus on a small and little-studied portion of the electromagnetic spectrum sandwiched between microwaves and infrared light. Such radiation is emitted by objects between 10 and 50 kelvin. "It's the cold universe. Stuff that is not close to stars and the gas and dust between stars," says Richard Hill, a project scientist at the Joint ALMA Office in Santiago, Chile.

But ALMA is more than just a bigger, better telescope. The project true to its first aim: to allow astronomers from across the world to work together to build a truly global facility.

ALMA's principal partners are the United States, Japan, and the European Southern Observatory (ESO), which represents 14 European nations plus Brazil. These three are joined by Canada and Taiwan as minor partners plus Chile as host. "It's the first truly world telescope," says Norio Kaifu, former director of the National Astronomical Observatory of Japan (NAOJ). Together, they are spending roughly \$1 billion to build 66 receiving dishes—most of them 12 meters across—in a roomy, frigid array spanning as much as 16 kilometers. If that weren't difficult enough, the site is an almost featureless 5000-meter-up-on-the-Chajnantor plain of Chile's Atacama Desert.

This month, the first 16 "antennae," as astronomers call them rather than dishes, will be declared operational, and researchers will get a taste of what ALMA can do. Even



High and dry, how the complete ALMA will look (left) and antennas awaiting installation (top).

with this small subset of the full array, ALMA "is better than any existing instrument, with much higher sensitivity and angular resolution," says ESO's ALMA project scientist, Leonardo Iltis. ESO's project manager for ALMA, Wolfgang Wild, says he is looking forward to "watching a planet in the stage of formation, seeing the dust disk clumping together. This is something for which millimeter-wave astronomy is uniquely suited."

It will be another 2 years before the full suite of 66 antennas is in place and ALMA's full power is available. Getting there has been a challenge on many levels: for the scientists and engineers who designed and built the array in the harsh conditions of Chajnantor; for the workers who had to build the road

tion. By looking at young stars surrounded by disks of gas and dust, astronomers can begin to answer questions about how those disks evolve into planetary systems. A key piece of this puzzle is the chemical composition of the gas and dust, and that is the target of University of Tokyo astrophysicist Satoshi Yamamoto. He and others have exhibited the chemical composition and evolution of molecular clouds up until just after the formation of a star. But then the gas and dust becomes so diffuse that it escapes detection by current instruments. "With ALMA, we will probably considerably enhance our understanding of the course of chemical evolution from the birth of a star to the formation of planets," says Yamamoto, whose team has been observing time in the early science phase.

At first, researchers will be able to look at only a few very nearby objects, but as ALMA grows, so will its ability to see more distant objects. Star formation is also "one of the areas where ALMA will really make a huge impact," says Fred Lo, director of the U.S. National Radio Astronomy Observatory (NRAO). He says that the limited sensitivity and resolution of existing telescopes has meant that current understandings of star formation "are based more on theory than observations." Observations with ALMA are likely to resolve current theoretical debates, he says.

Other targets include the very earliest galaxies in the universe, which are obscured from optical telescopes by gas and dust. Astronomers want to find out how they coalesce from the interstellar medium and acquire a structure. At first only the brightest, largest, and most massive will be visible, but the full ALMA will bring normal-sized galaxies like our Milky Way into view. Then astronomers will be able to track the evolution of such galaxies through the history of the universe.

Some results could hit much closer to home. Several groups hope to use ALMA to search interstellar space for the telltale signals of amino acids, the building blocks of life. "Was the origin of life unique to Earth, or did it exist in cosmological space?" asks Satoru Igarashi, ALMA project manager at NAOJ. The theory is that glycine and other amino acids could have been created in interstellar space. These elements could have formed down on protoplanets or been scattered from the comets by comets, according to life on any planet with favorable conditions. Groups have tried but failed to spot amino acids using existing telescopes. "If someone were to succeed in this [observation], it would change astronomy right now," says Igarashi. And a new instrument almost always



On the move: A crane lifts a 100-ton antenna at night, hoisted by a 100-ton crane. Workers are seen in the foreground.

bring surprises. "We are talking about distant galaxies, planetary disks, life-related molecules, but, in fact, we shouldn't be surprised to find something completely unexpected," says Masao Saito, NAOJ's ALMA project scientist.

The final proposal for the early science phase reflects efforts by ALMA managers to make the facility accessible to all astronomers, not just millimeter-wave specialists. The project has set up ALMA Regional Centers (ALRCs) in Europe, Japan, and the United States—"We wanted to get as close to the user community as possible," De Graw says—and researchers apply for observing time through Web sites connected to each ALRC. A single review committee reviews the applications and makes them by scientific merit. Then observing time is split in proportion to each region's contribution to the project (33.75% each for North America and ESO, 22.9% for East Asia, and 10% for Chile).

The lucky researchers who do get observing time won't need to buy or build; they will just have to sit and wait. Operations staff members in Chajnantor divide all the requested observations into "blocks" and schedule them according to what's in the sky, which antennas are needed, and what configuration they are in. Astronomers may have to wait for months for their data, which are delivered via their local ALRC. "This will be remote observing, with only support work done at the site," Caltech's Sargent says.

### Down and up

ALMA managers are quietly confident that, barring mishap, their project is going to make a safe landing. "In general, it's going quite good—although the proof of the pudding is in the eating," De Graw says. But

if the project is on firm ground now, the road to the high Atacama plateau hasn't always been smooth. In 2005, the project hit a sticky patch when astronomers were disappointed with the results of testing prototype antennas (Science, 19 May 2006, p. 990).

More tests were carried out, but during the delay the cost of construction such as steel and labor in Chile skyrocketed. The project was forced to go back to its funders and ask for more money. They agreed, but the project was "reshuffled" with a new schedule, a 40% funding increase, and a painful cut of the main array from 64 antennas to 50.

Learning to work together also took a lot of time and effort. "Each party has a different culture, a different method of making budget requests," NAOJ's Miyazaki says. "There were lots of negotiations." What carried them through, NRAO's Lo says, was "a lot of purpose." From the beginning, the three observatories at the core of the group—ESO, NRAO, and NAOJ—had each started work on a large millimeter-wave array. The initial ideas were very similar, Lo says, making it easy to agree to work together. Yet because the three observatories had different goals, project managers, and experience in building and operating major facilities, Lo says, it made sense to let each take responsibility for a piece of the project rather than force them under an overall management structure.

Now the pieces are coming together, as the scientists and engineers building ALMA buckle down to complete their array and start producing scientific results. "The moment that we get the image of a disk around a protostar and see giant planets forming, that'll be a magical moment," Hill says.

—DENNIS NORMALE AND DANIEL CLERY

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PHOTO: ALMA OBSERVATORY

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# Start Early Science Operation

on September 30, 2011

- Japanese EPO Activities
  - The news programs on ALMA filmed at the OSF were broadcasted by NHK (Japan Broadcasting Corporation) on October 3 and 19. These programs were received favorably by the viewers and helped increase name recognition.



On October 19, new documentary focused on ALMA



# Cycle 0 Capability

- CfP 2011 Mar 30, proposal deadline 2011 Jun 30
- 2011 Sep 30 to 2012 Jun 30 (9 months)
- Allocate 550 hours of array time
- 16 x 12m antenna array
- 18-125m, 36-400m baselines, 2 configurations
- Single field imaging and Mosaics up to 50 fields
- Frontend
  - Band 3 (2SB: 84GHz - 116GHz)
  - Band 6 (2SB: 211GHz - 275GHz)
  - Band 7 (2SB: 275GHz - 373GHz)
  - Band 9 (DSB: 602GHz – 720GHz)
- Set of ~14 spectral modes (same setting for all baseband)
- **No single dish, No polarization, No special modes**
- Amp Calibration good to 5% (band 3) and less accurate at high frequencies. The goals are: better than 10% in bands 6 and 7, and better than 20% in band 9.

**All risk shared!**  
**Not yet Data Quality Control**



# Cycle 1 Capability (TBD)

We will announce the final Cycle 1 capability on next Dec.

- CfP **2012 Feb 1**, proposal deadline **2012 Mar 27** (currently)
- **2012 Aug 1 to 2013 Apr 30** (9 months)
- Be anticipated that **1300** hours of array time
- **32 x 12m antenna array + 6 x 7m antennas (ACA)**
- 18-**750** m baselines, **continuous** configurations
- Single field imaging and Mosaics up to **150** fields
- Frontend
  - Band 3 (2SB: 84GHz - 116GHz)
  - Band 6 (2SB: 211GHz - 275GHz)
  - Band 7 (2SB: 275GHz - 373GHz)
  - Band 9 (DSB: 602GHz - 720GHz)
- Set of ~**many** spectral modes (different setting for each baseband)
- **Single dish (line), Linear polarization, Solar Observations**
- Amp Calibration **better than Cycle 0**

on ACA only

**Band 4 (2SB: 125GHz - 163GHz)**

**Band 8 (2SB: 385GHz - 500GHz)**

Demonstration science based on Proposal?

Demonstration science based on Proposal?

**Risk shared**

**Not yet Data Quality Control**

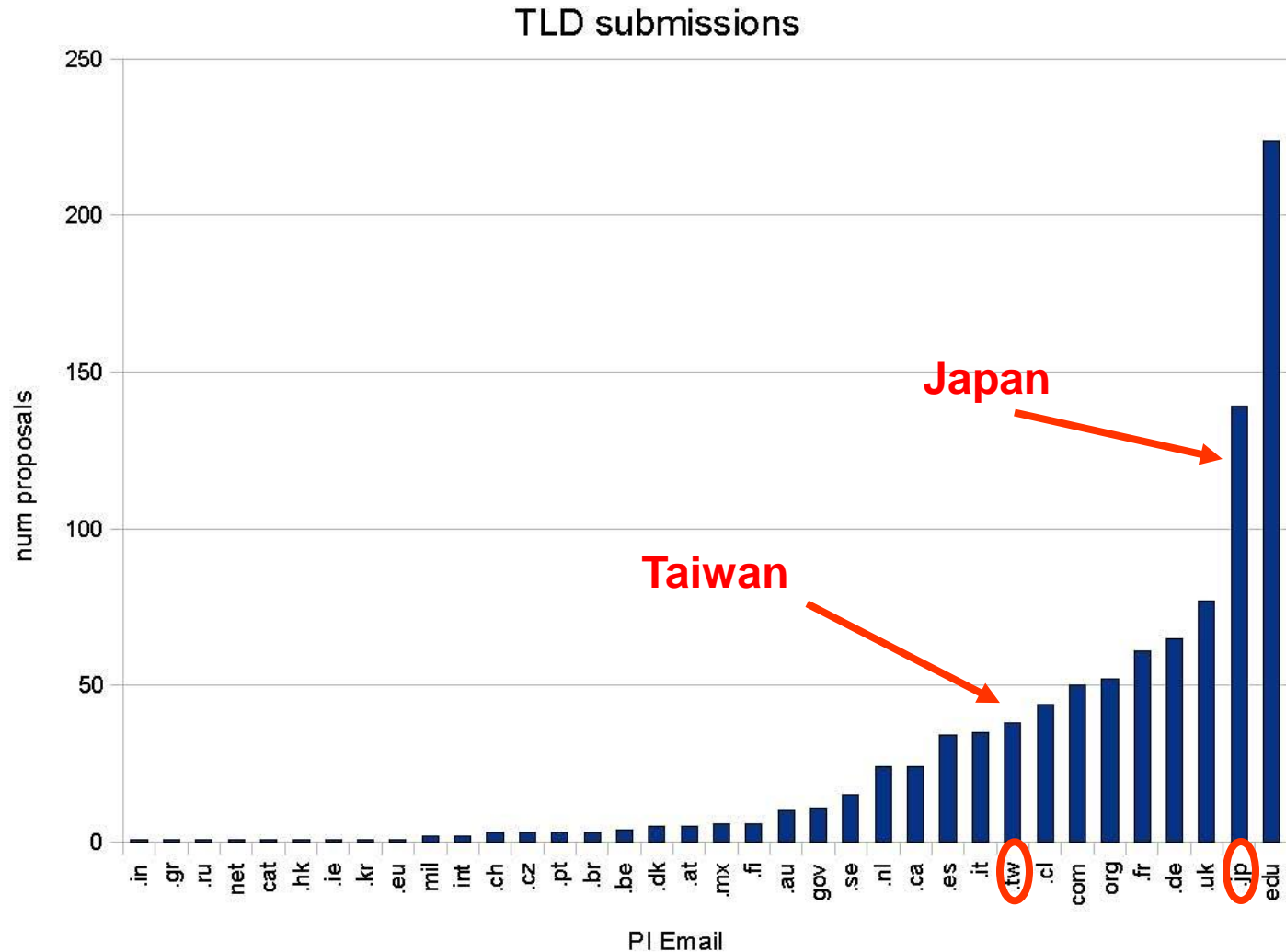


# EA Science activities



# First Call for Proposal (Cycle0)

## Submitted proposals







# Submitted proposals (Cycle0)

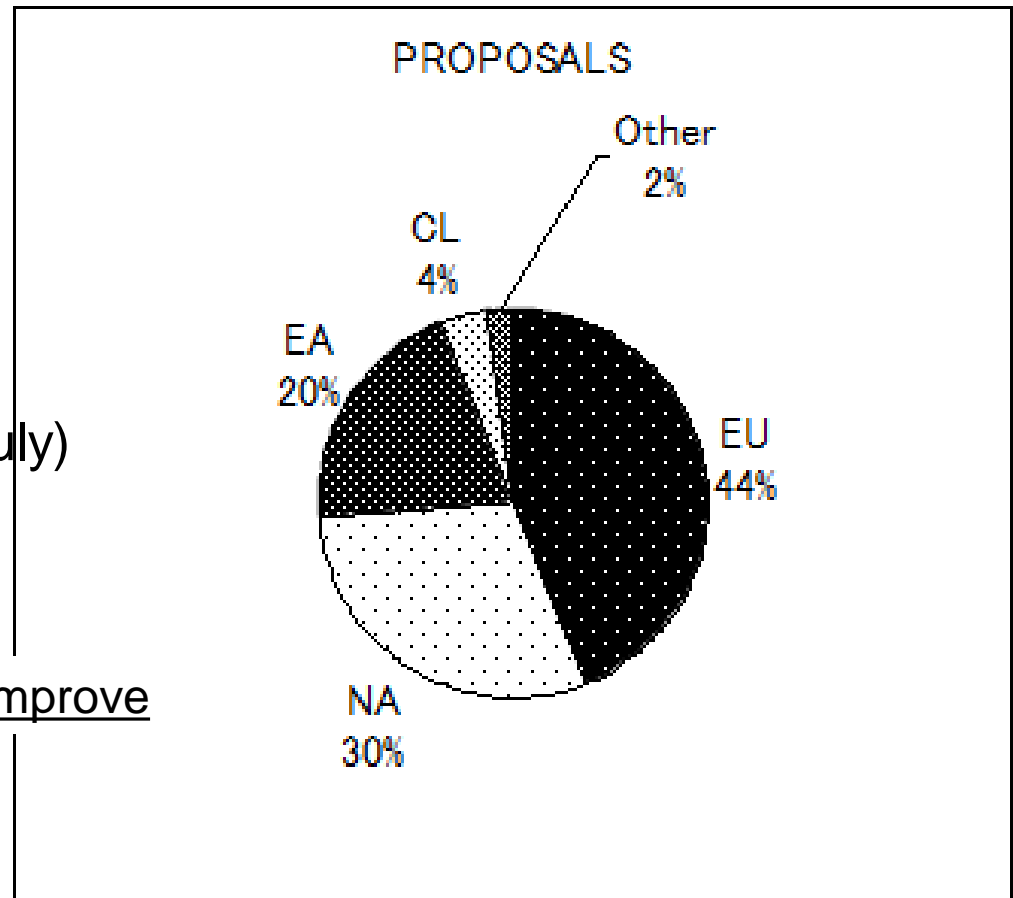
- Total 923 proposals (5 July)

- EU 404 (44%)
- NA 279 (30%)
- EA **184 (20%)**
- CL 35 (4%)
- Others 21 (2%)

- Total registration 2898 (1 July)

- EU 1260
- NA 980
- EA **400**
- CL 52
- Others 206

Need to improve





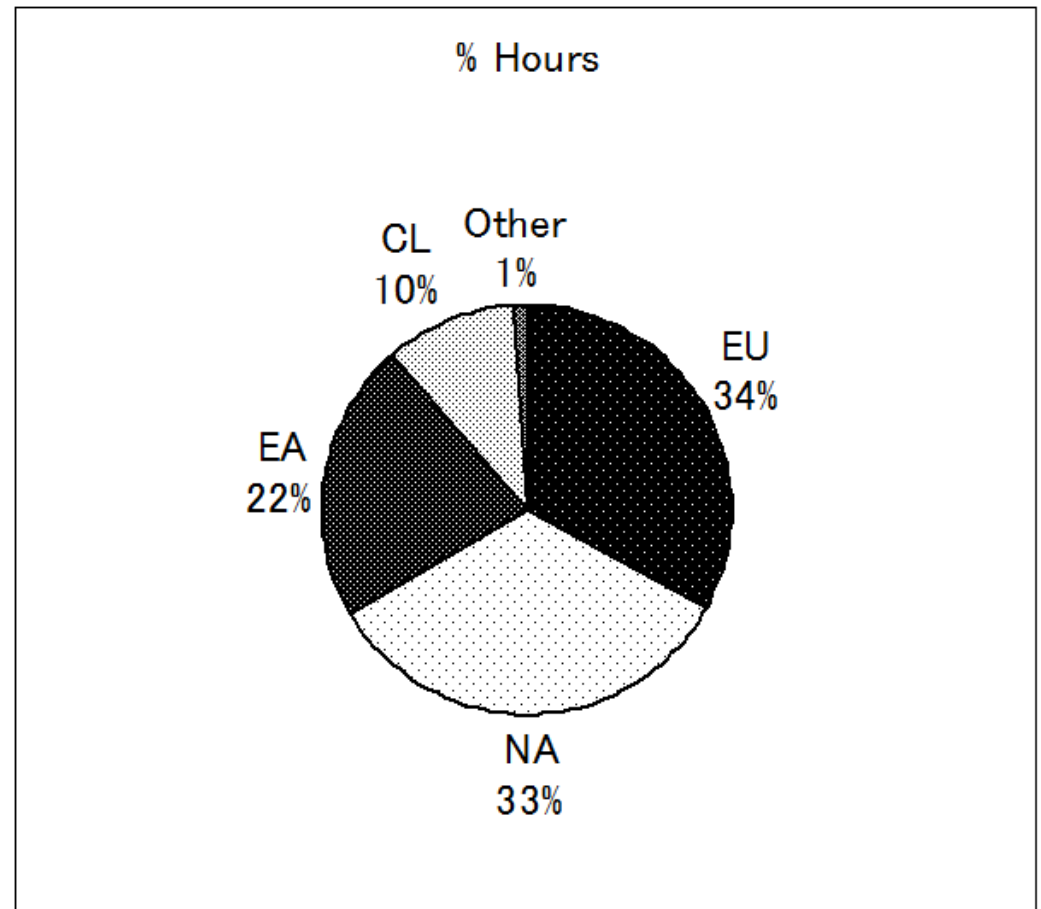
# Accepted proposals (Cycle0)

- Total 112 proposals (“highest priority”; 505.5 h)

- EU 35 (167.5 h)
- NA 38 (168.5 h)
- EA **27** (111.3 h)
- CL 11 (52.3 h)
- Others 1 (5.9 h)

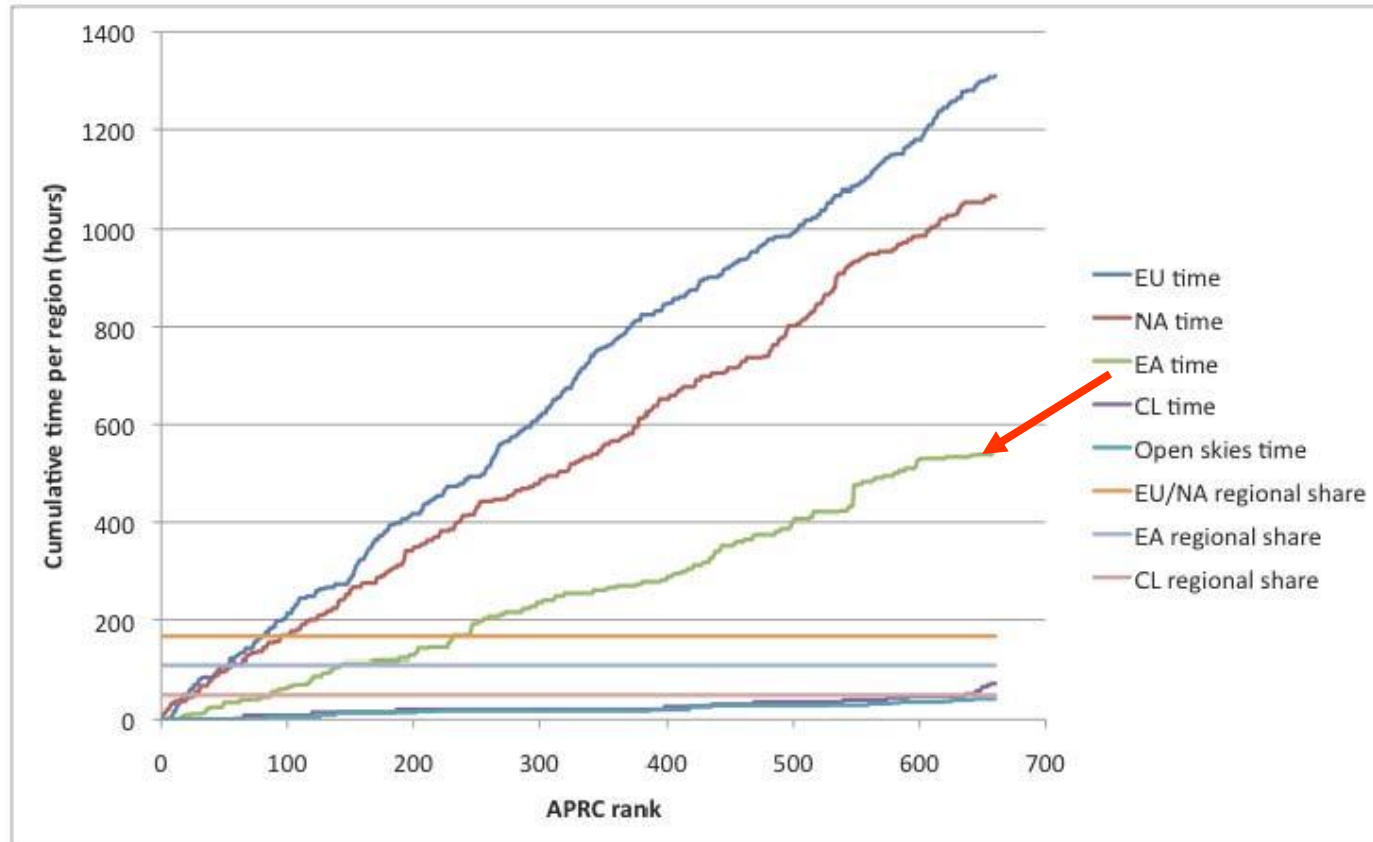
- Top 100 proposals

- EU 43
- NA 38
- EA **16**
- CL 2
- Others 1



# Proposal Review for Cycle 0

## Accepted proposals



We need to submit more proposals to increase the top-100 ranks from EA.



[www.almaobservatory.org](http://www.almaobservatory.org)

*The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership among 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 Japan by the National Institutes of Natural Sciences (NINS) 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.*