

# ALMA: Atacama Large Mm/submm Array

Current Status and Overview For Cycle I



**Kim Scott**  
**North American ALMA Science Center**  
**National Radio Astronomy Observatory**

Atacama Large Millimeter/submillimeter Array  
Expanded Very Large Array  
Robert C. Byrd Green Bank Telescope  
Very Long Baseline Array



## The take-away message in one slide

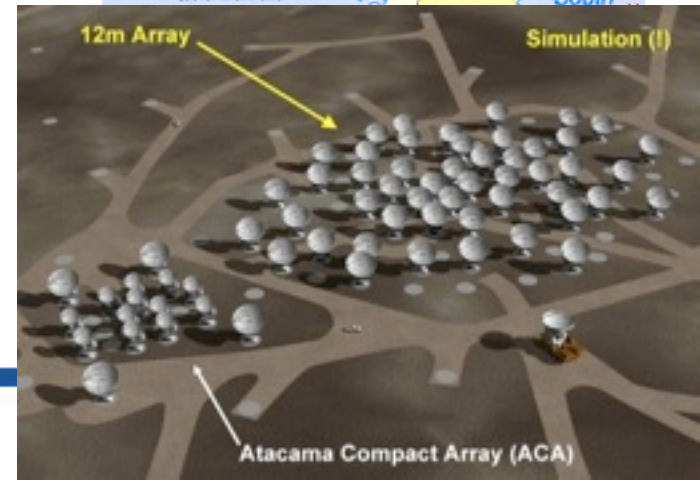
- ALMA is operating now!
- Accepted proposals for ALMA Cycle 0 began observations 30 Sept
- Proposals for ALMA Cycle I: due sometime in 1<sup>st</sup> half of 2012
  - ALMA Science Portal at <https://almascience.nrao.edu>
- Cycle 0 observing ends late 2012
- Cycle I observing begins afterwards

## Talk Outline

- **ALMA Overview**
- ALMA Status & Test Data
- Cycle I Capabilities under Discussion
- Proposal Logistics, Support from the NAASC
- Future Capabilities of ALMA

# ALMA Overview

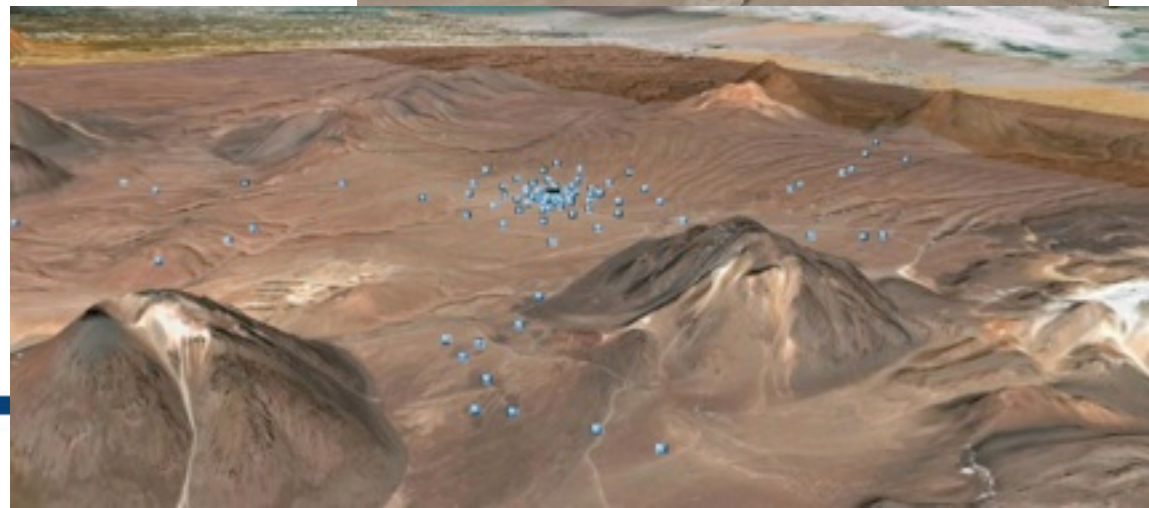
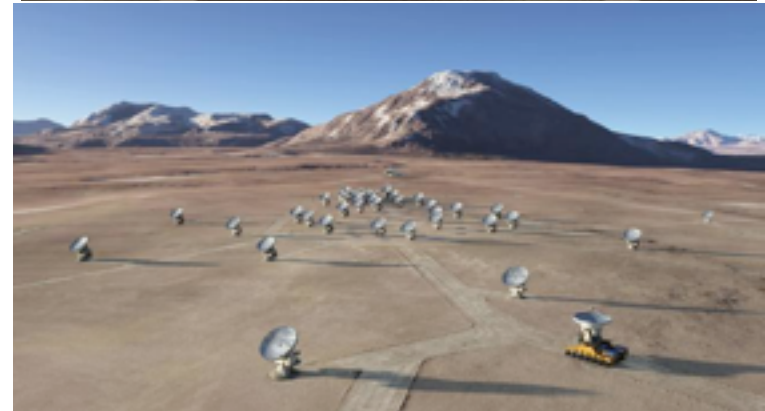
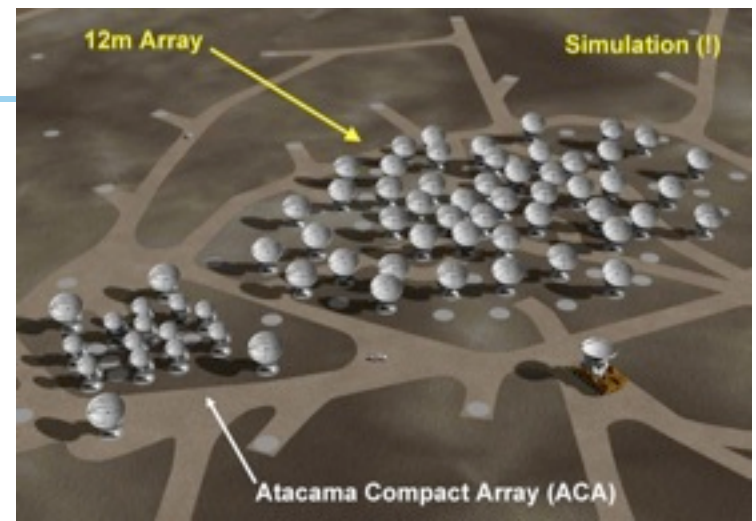
- A global partnership to deliver a transformational millimeter/submillimeter interferometer
  - North America (US, Canada, Taiwan)
  - Europe (ESO)
  - East Asia (Japan, Taiwan)
  - In collaboration with Chile
- 5000m (16,500 Ft) site in Chilean Atacama desert
- Main Array: 50 x 12m antennas
  - + Total Power Array 4 x 12m
  - + Atacama Compact Array (ACA): smaller array of 12 x 7m antennas
- Total shared cost ~1.3 Billion (\$US2006)
- On budget for completion on time





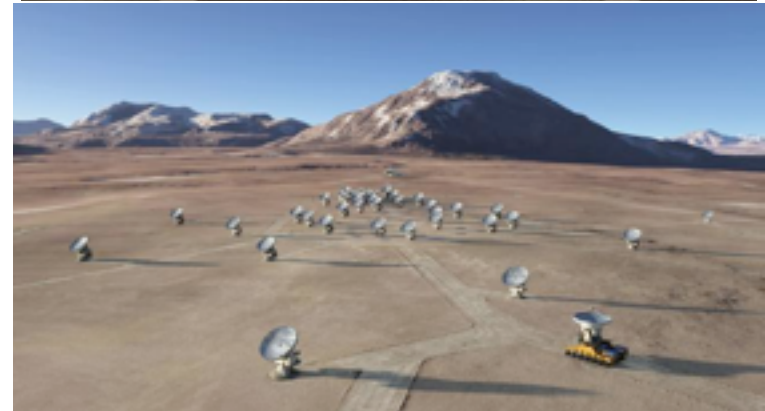
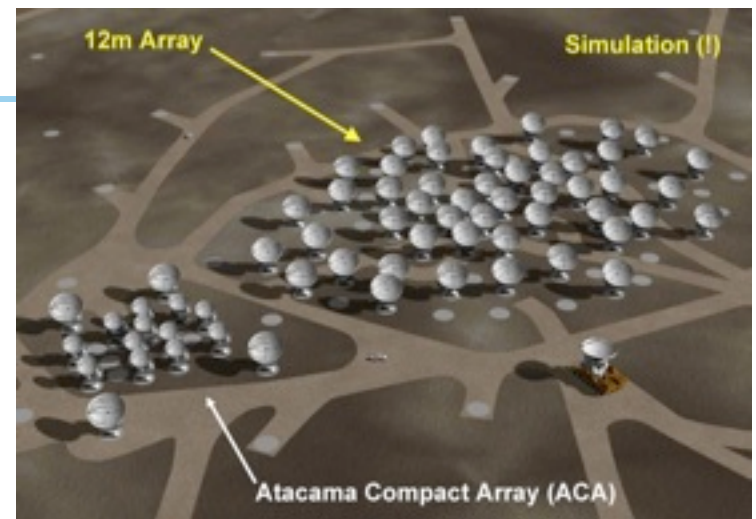
# ALMA Overview

- Baselines up to 15 km (0.015" at 300 GHz) in “zoom lens” configurations
- Sensitive, precision imaging 84 to 950 GHz (3 mm to 315  $\mu\text{m}$ )
- State-of-the-art low-noise, wide-band SIS receivers (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities
- Estimate 0.5 TB/day archived



# ALMA Overview

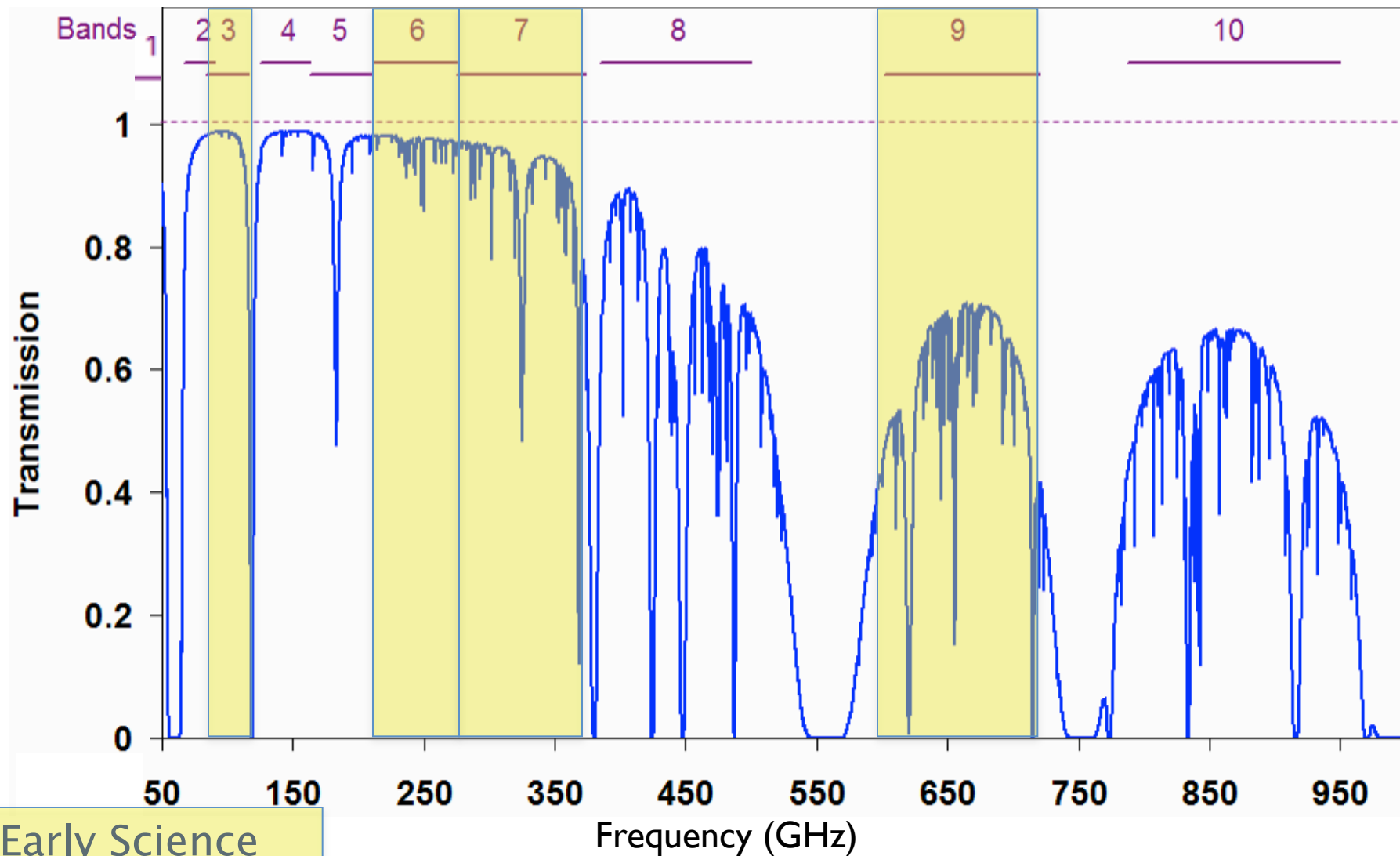
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- Sensitive, precision imaging 84 to 950 GHz (3 mm to 315  $\mu$ m)
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- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities
- Estimate 0.5 TB/day archived
- A resource for ALL astronomers



ALMA will be 10-100 times more sensitive and have 10-100 times better angular resolution compared to current millimeter interferometers

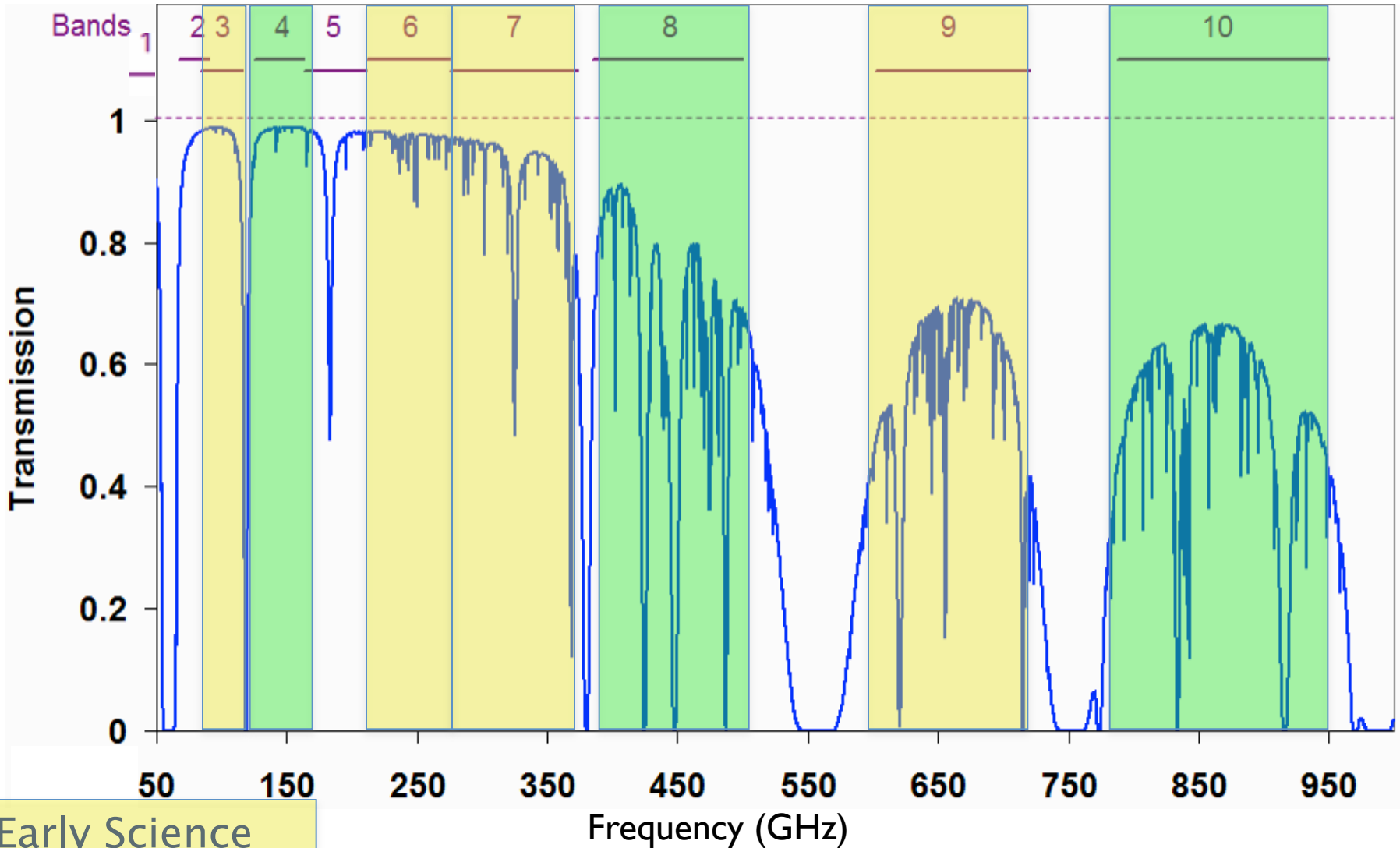


# ALMA Receiver Bands



Early Science

# ALMA Receiver Bands



Early Science

Full Operations



# ALMA in Context


## Collecting Area

# of antennas  
 (# of baselines)

➤ Sensitivity goes as  
 collecting area

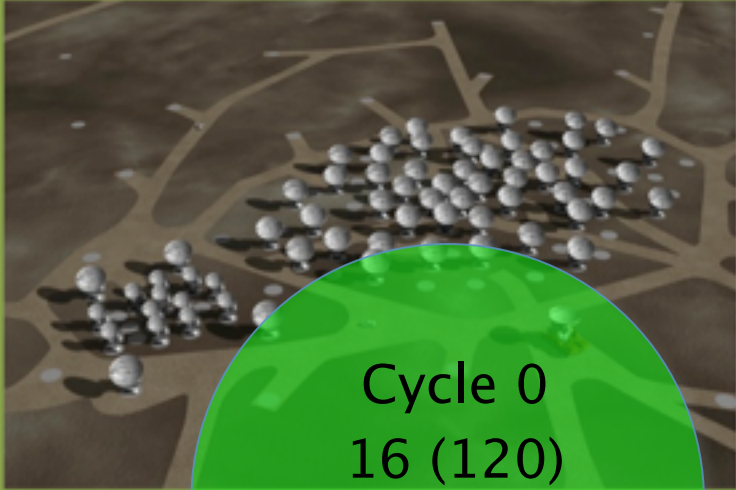
➤ Image fidelity goes  
 as # of baselines

**SMA**  
  
 8 (28)


**CARMA**  
  
 23 (253)

**IRAM PdBI**  
  
 6 (15)

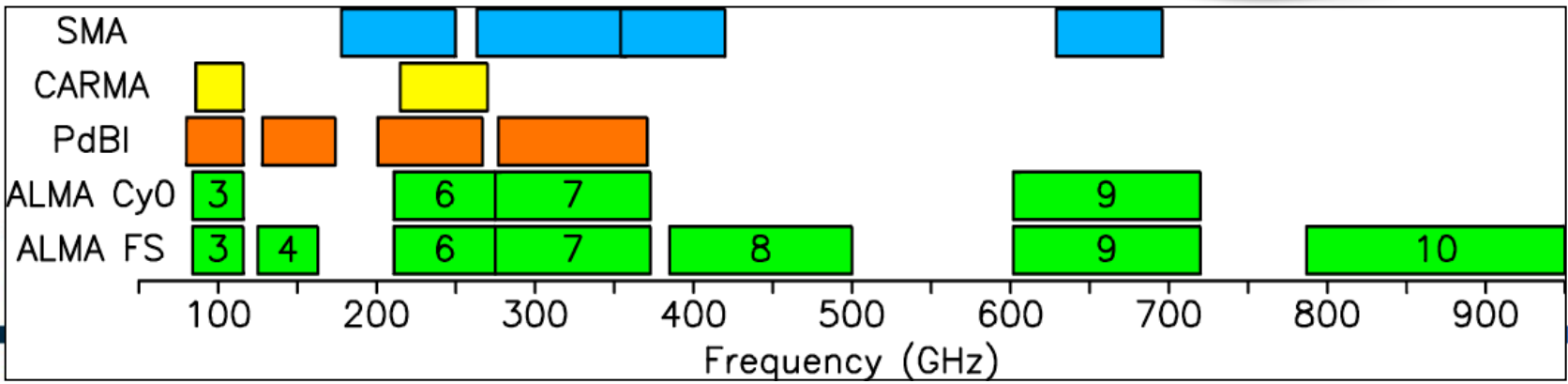
**ALMA**  
 Full Science  
 64 (2016)



**Cycle 0**  
 16 (120)



## Spectral Coverage



# ALMA in Context


## Collecting Area

# of antennas  
 (# of baselines)

➤ Sensitivity goes as  
 collecting area


➤ Image fidelity goes  
 as # of baselines

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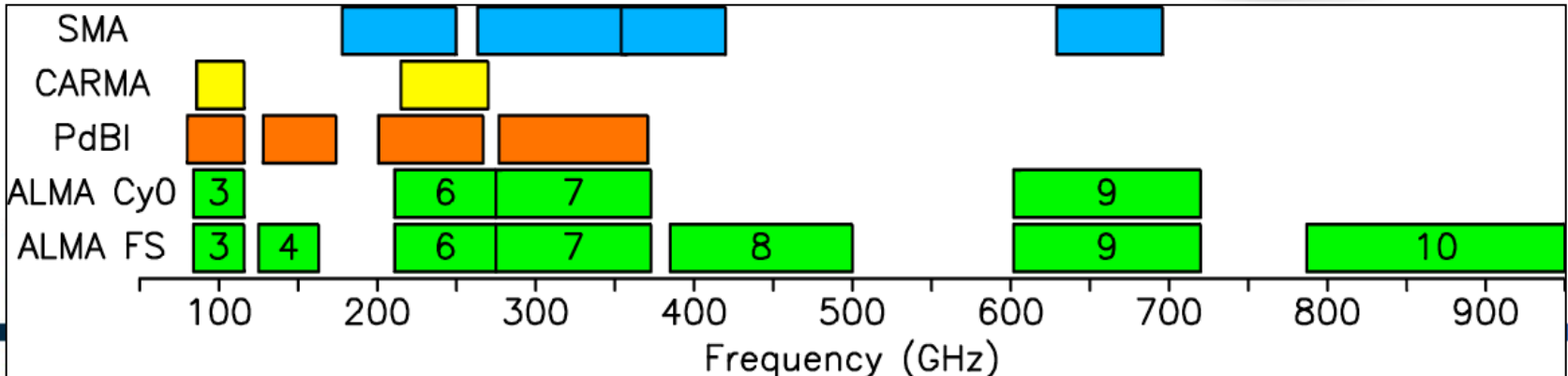


**Cycle I**  
 32 (496)

**Cycle 0**  
 16 (120)



## Spectral Coverage

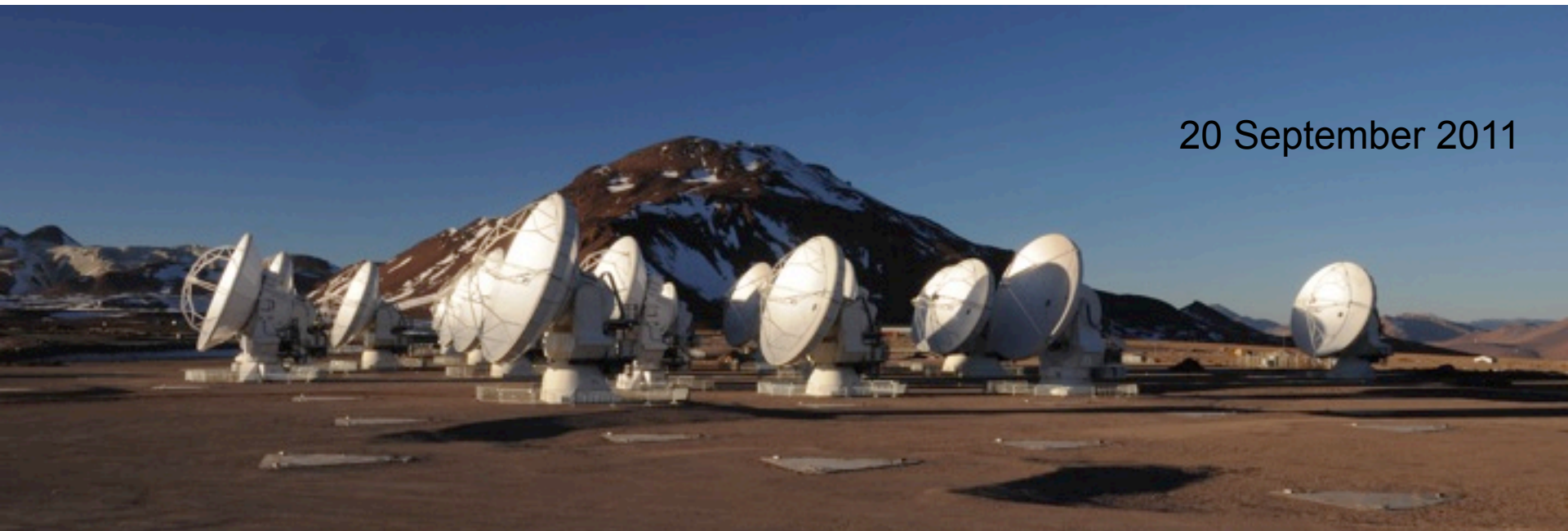


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- **ALMA Status & Test Data**
- Cycle I Capabilities under Discussion
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## Current Status

- ALMA Cycle 0 observations began 30 Sept 2011
- Commissioning and science verification ongoing



20 September 2011

## Current Status

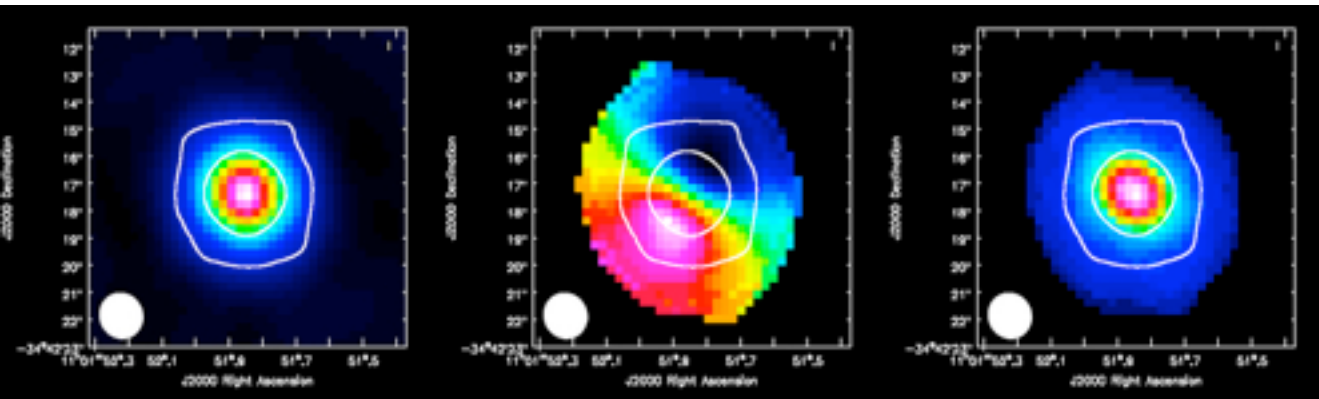
- 26 antennas at the Array Operations Site (AOS)
  - 21 x 12m antennas in ES compact configuration
  - 5 x 7m antennas of ACA
- > 51 antennas in various stages of completion
- Correlator/spectral modes
  - Both ACA and 64 element correlators functioning
  - All antennas equipped with B3, B6, B7, and B9 receivers
- Data products for first Cycle 0 projects delivered to PI's



# Science Verification Data

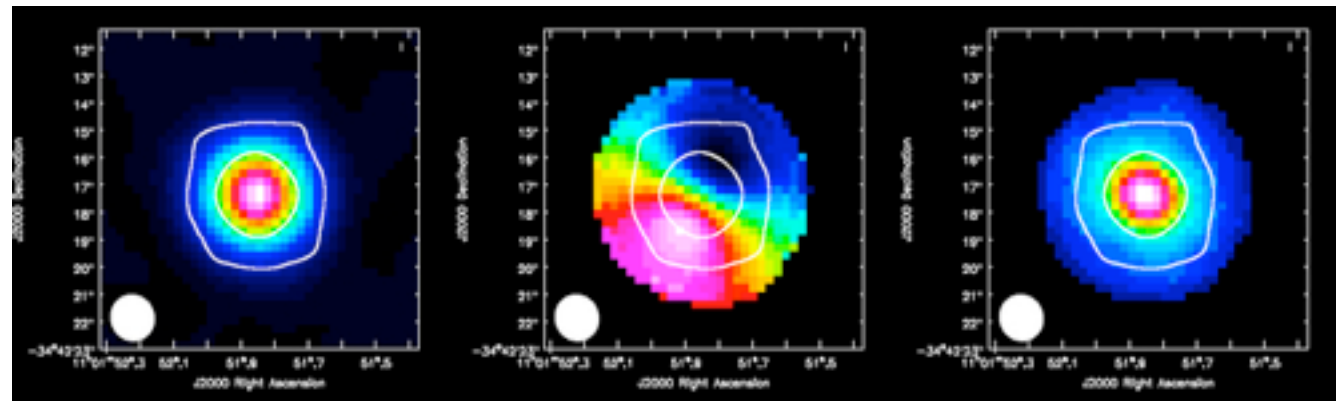
- Five datasets released
  - 1: **TW Hya: Band 7, high spectral resolution (casaguide)**.  
Meredith Hughes, Stuartt Corder, Chunhua Qi, Karin Oberg, Michiel Hogerheide, Andrea Isella, Dmitry Semenov.
    - Additional data on TW Hya is available (without a separate CASA guide) here: Band 3, Band 6.
  - 2: **NGC3256: Band 3, low spectral resolution (casaguide)**.  
Kazushi Sakamoto, Alison Peck, Satoki Matsushita, Martin Zwaan.
  - 3: **Antennae galaxies: Band 7, high spectral resolution (casaguide)**.  
Christine Wilson, Junko Ueda, Francois Boulanger, Nicole Nesvadba, Cinthya Herrera.
- Look for updates on Science Portal:
  - <https://almascience.nrao.edu/alma-data/science-verification>

# TW Hya 350 GHz SV Data



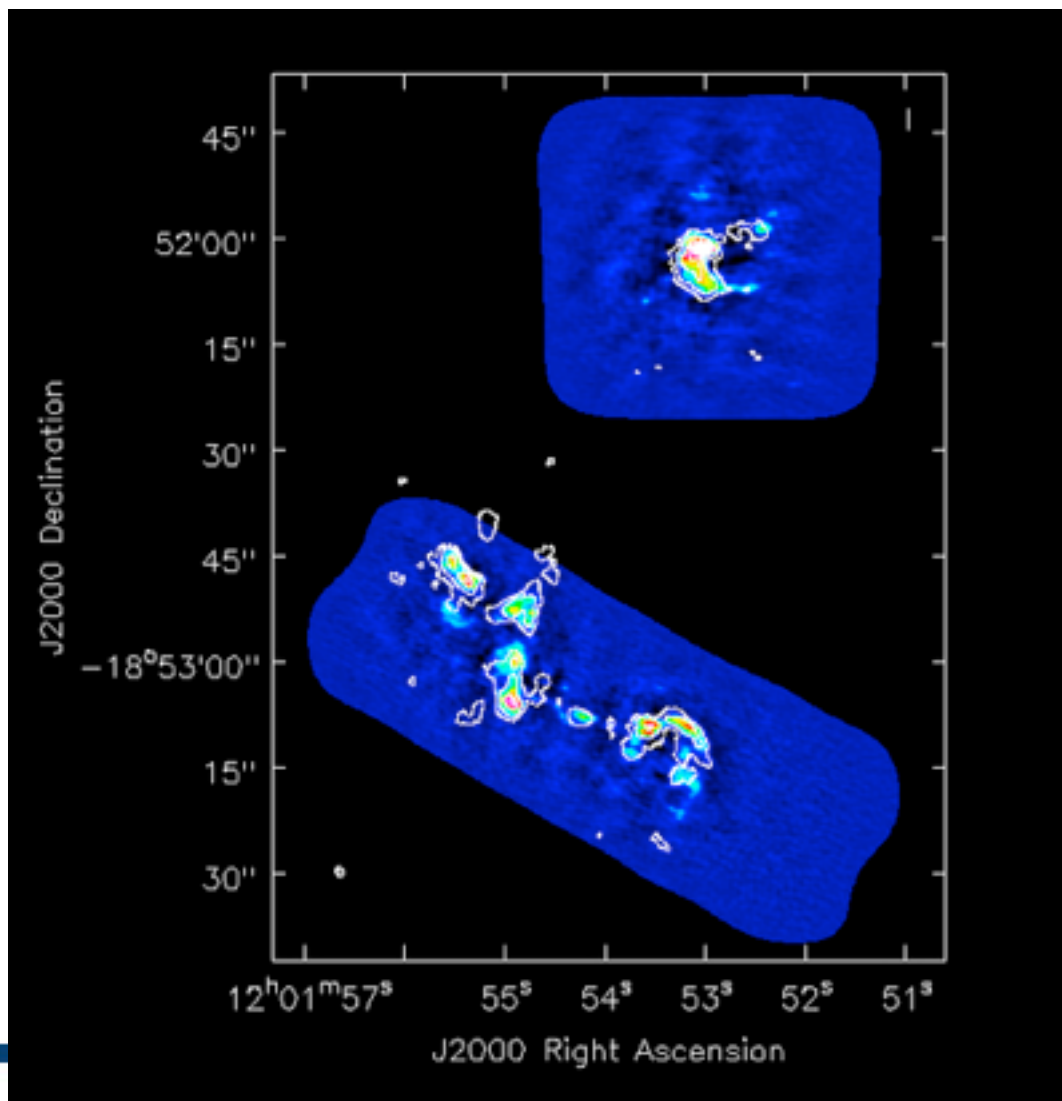
CO J=3-2 in TW Hya:  
**left** - integrated intensity; **center** - intensity-weighted velocity field; **right** - intensity-weighted velocity dispersion. Continuum is superposed as contours.

HCO+ J=4-3 in TW Hya:  
**left** - integrated intensity; **center** - intensity-weighted velocity field; **right** - intensity-weighted velocity dispersion. Continuum is superposed as contours.



## The 'Antennae': SV Data

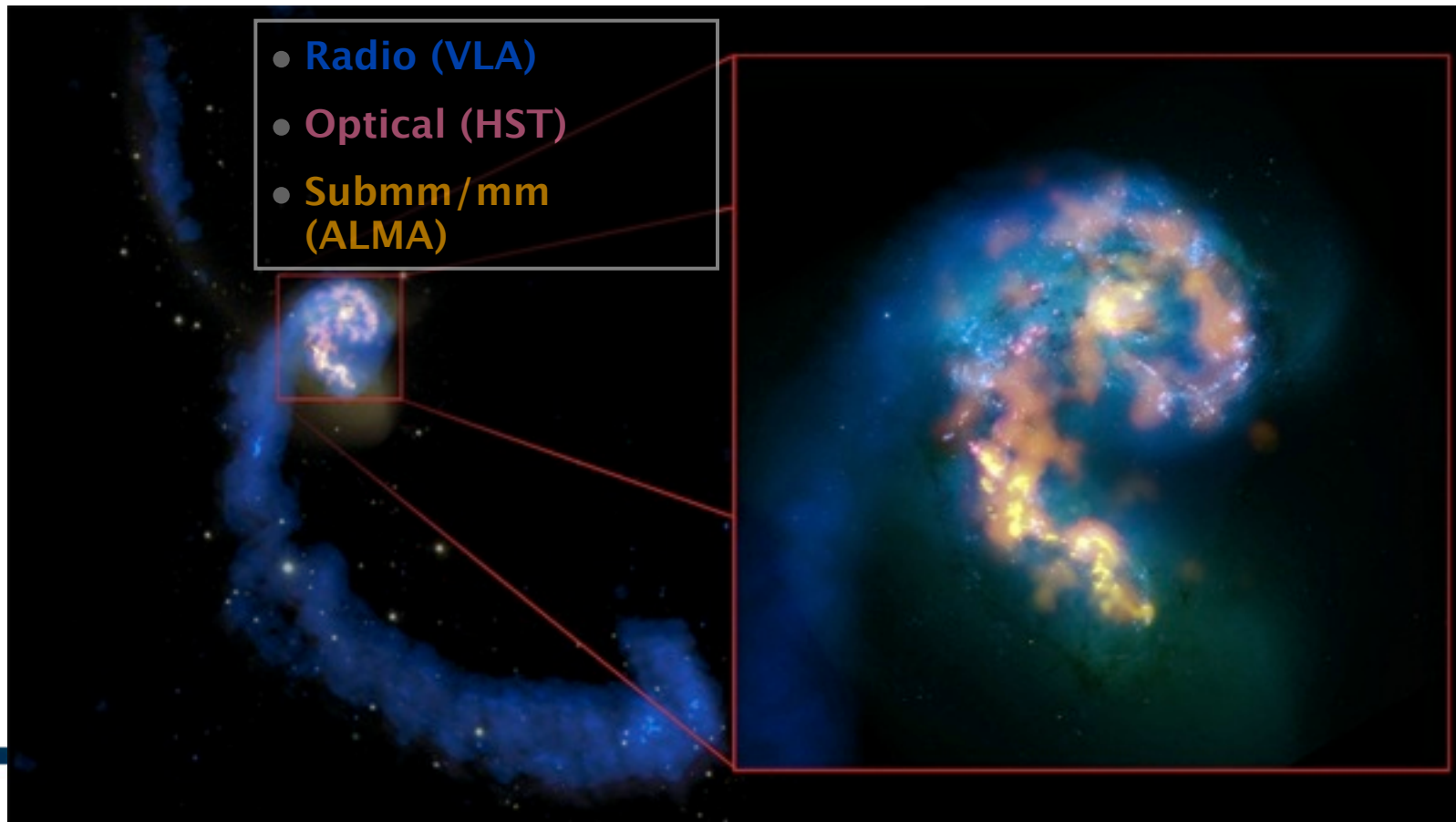
The CO(3-2) total intensity map (moment 0) comparison with SMA data. Color image is ALMA data, combining southern and northern mosaics. Contours show SMA data (Ueda, Iono, Petitpas et al., submitted to ApJ, [arXiv1110.2496](https://arxiv.org/abs/1110.2496)).



# The 'Antennae': SV Data

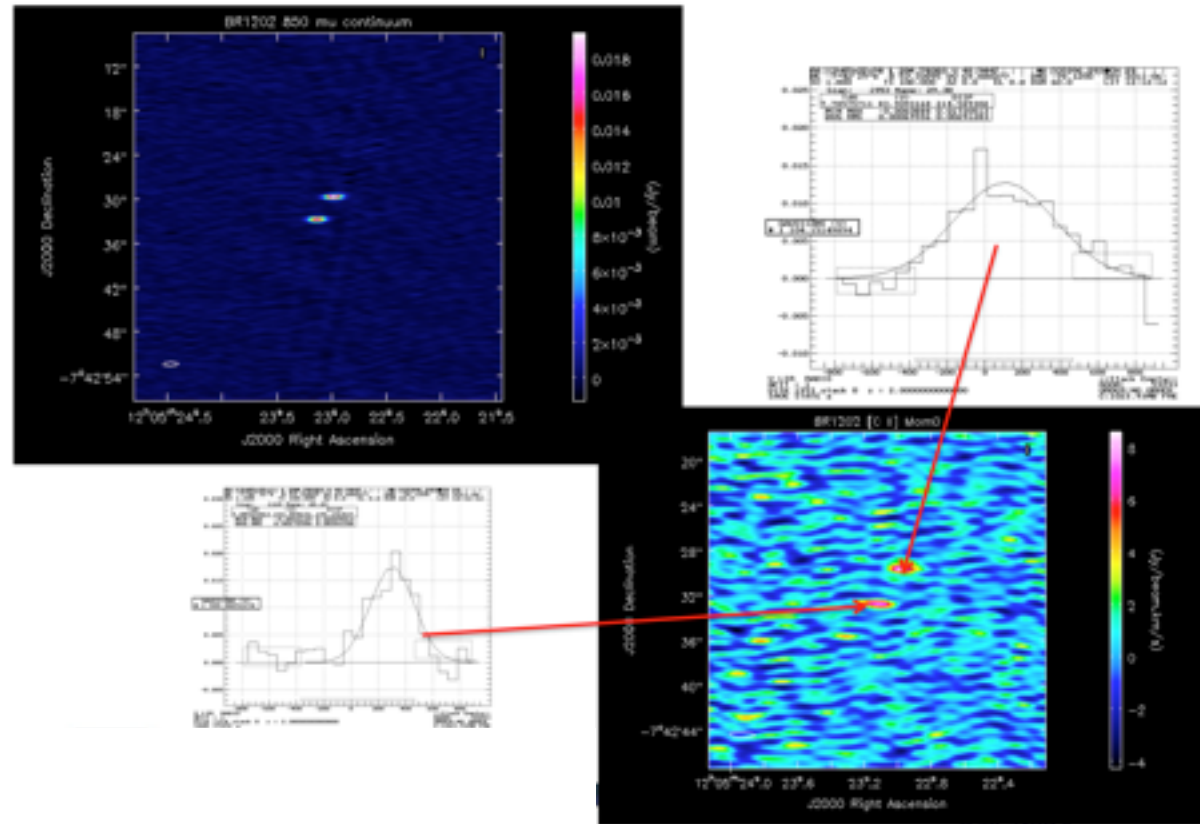
- Press Release – See [NSF link](#) for science discussion

CREDIT: NRAO/AUI/NSF; ALMA (ESO/NAOJ/NRAO); HST (NASA, ESA, and B. Whitmore (STScI)); J. Hibbard, (NRAO/AUI/NSF); NOAO.



# BRI 202: [CII] at $z = 4.7$ (not released)

- Matches SMA results (Iono et al. 2006), and is of higher quality
- However, some data taken at elevation  $10^\circ$  – does not meet Quality Assurance requirements necessary for User data





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## Cycle I: Plans (Proposed)

- Proposal deadline: **sometime in 1st half of 2012**
- Starts **after Cycle 0 ends**
- Duration: **~10 months**
- Total time for science observations: **~1500 hrs**
- Programs supported
  - Standard Proposals
  - Target of Opportunity (ToO)
  - Director's Discretionary Time (DDT)
  - Time critical observations, with scheduling sharpness of 1–2 weeks
- Programs not supported
  - Large programs (>100 hrs)
  - Highly rated Cycle 0 proposals will not be carried over to Cycle 1
  - Highly rated Cycle 1 proposals will not be carried over to Cycle 2

# Cycle I: Antennas and Array Configurations (Proposed)

- Number of antennas
  - 32 x 12m antennas for main array
  - At least 6 x 7m antennas for ACA
  - 1 x 12m ACA antenna for zero-spacing observations (single-dish)
- 12m array configurations
  - Maximum baseline lengths: 150m – 1km
  - Configurations: TBD; expect ~4–9 configurations
  - PIs will apply for required angular resolution and largest angular scale, not specific configuration
- ACA capabilities
  - Single configuration, designed to fill in short-spacings not covered in the compact configuration of 12m array
  - Single-dish observations: for spectral-line data only
  - Only used in combination with 12m array

# Cycle I: Receiver and Correlator Capabilities (Proposed)

- Bands 3, 6, 7, and 9 (same as Cycle 0)
- Correlator
  - Add capability to do spectral averaging
  - Independent bandwidth/resolution in four basebands
  - Independent baseband tuning, sideband separation

Band	Frequency (GHz)	Primary beam (arcsec)	Angular Resolution (arcsec)	Continuum Sensitivity (mJy min <sup>1/2</sup> )
3	84 - 116	62	0.6 - 4.1	0.09
6	211 - 275	25	0.3 - 1.7	0.14
7	275 - 373	19	0.2 - 1.2	0.25
9	602 - 720	9	0.1 - 0.6	2.5

# Cycle I: Observing Modes (Proposed)

## 1. Single-field interferometry

- Sources separated by  $<15^\circ$  – maximum of 15 sources per Science Goal
- Sources separated by  $>15^\circ$  – 1 source per Science Goal

## 2. Mosaics

- Maximum of 150 pointings per Science Goal

- **Maximum of 5 Science Goals per proposal**



# Cycle I: Observing Modes NOT Supported

- Spectral sweep mode
- Polarization
- Solar observations

While these modes will not be offered in Cycle 1, dedicated campaigns to test these capabilities will be carried out during this period.

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# ALMA Cycle 0/I Timeline

Date	Milestone
30 September 2011	Start of ALMA Cycle 0 observing (compact configuration)
February 2012	Engineering shutdown
March 2012	Recommence Cycle 0 observing (extended configuration)
1st half of 2012	Cycle I CfP; release of new OT and proposers guide
	Cycle I proposal deadline; technical assessment and proposal review process
Late 2012	End of ALMA Cycle 0; start of Cycle I

# Proposal Checklist

- Read Primer and Proposers Guide
- Create ALMA account by registering at the Science Portal
- Download Observing Tool (OT), try Sensitivity Calculator
- Download CASA 3.3 (current release), try simdata
- Prepare the Science & Technical Justifications (one PDF file)
- Prepare Science Goals (sources, frequency & correlator setup, integration times) within the OT
- Make use of the Helpdesk & the Knowledgebase
- Submit to Archive!

# Science Portal (<https://almascience.nrao.edu>)



Welcome to the ALMA Science Portal at NRAO — ALMA Science Portal

<https://almascience.nrao.edu/>

Search Site

Portals: ESO **NRAO** NAOJ

Log in Register Reset password

## Welcome to the ALMA Science Portal at NRAO



Atacama Large Millimeter/Submillimeter Array  
In search of our Cosmic Origins

Home

- About ALMA
- ALMA Science
- Call for Proposals
- ALMA Data
- Documents & Tools

User Services at ARCs

- Helpdesk
- EU ARC
- NA ARC
- EA ARC

ALMA for the Public



**Overview**

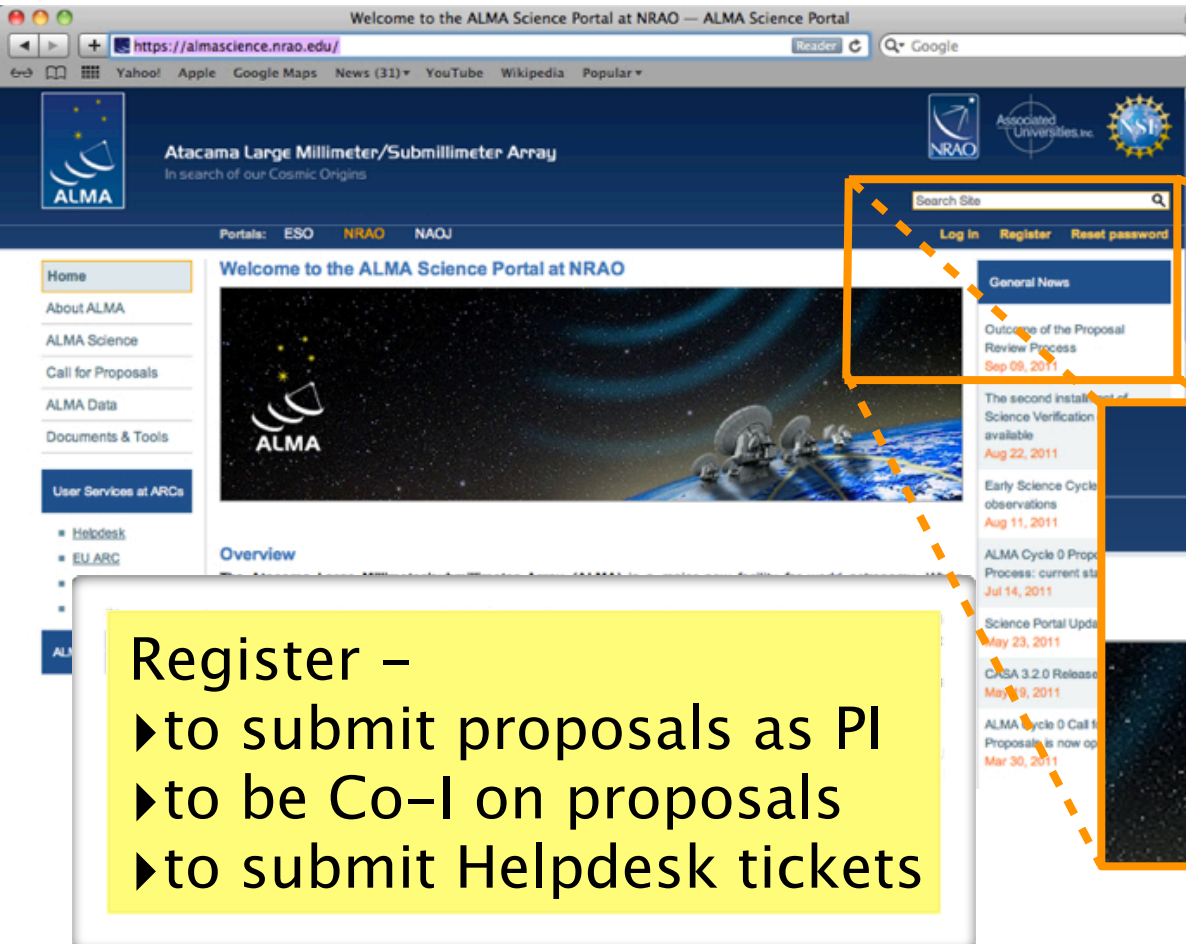
The Atacama Large Millimeter/submillimeter Array (ALMA) is a major new facility for world astronomy. When completed in 2013, ALMA will consist of a giant array of 12-m antennas, with baselines up to 16 km, and an additional compact array of 7-m and 12-m antennas to greatly enhance ALMA's ability to image extended targets. ALMA in Cycle 0 is outfitted with state-of-the-art receivers that cover atmospheric windows from 84–720GHz (3mm – 420 micron). Construction of ALMA started in 2003 and will be completed in 2013. Science observations will start in 2011 with 16 antennas and four receiver bands. The ALMA project is an international collaboration between Europe, East Asia and North America in cooperation with the Republic of Chile. More details can be found via the **About ALMA** link in the left menu.

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ALMA Science

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ALMA Data

Documents & Tools

User Services at ARCs

- Helpdesk
- EUARC

Portals: ESO **NRAO** NAOJ

Welcome to the ALMA Science Portal at NRAO

Overview

Register –

- ▶ to submit proposals as PI
- ▶ to be Co-I on proposals
- ▶ to submit Helpdesk tickets



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Log In Register Reset password

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# Science Portal

## Documents & Tools



The screenshot shows a web browser window displaying the ALMA Science Portal. The page title is "Summary of documents and tools available for ALMA". The navigation menu on the left includes "Home", "About ALMA", "ALMA Science", "Call for Proposals", "ALMA Data", "Documents & Tools" (highlighted), and "User Services at ARCs". The "Documents & Tools" section contains the following content:

- Call for Proposals**  
Documentation supporting the ALMA Call for Proposals for Cycle 0.
  - ALMA Cycle 0 Proposers Guide (Contains all pertinent information regarding the ALMA Cycle 0 Call for Proposals)
  - ALMA Cycle 0 Technical Handbook (A comprehensive description of the ALMA observatory and its components)
  - Early Science Primer (Introduction to interferometry and how to use ALMA during Early Science)
- Observing Tool (OT)**  
The ALMA Observing Tool (OT) is a Java application used for the preparation and submission of ALMA Phase I (observing proposal) and Phase II (telescope runfiles for accepted proposals) materials. The current Cycle 0 release of the OT is configured for the Early Science [Capabilities of ALMA](#). Note that in order to submit proposals you will have to register with the ALMA Science Portal beforehand.
  - ALMA Observing Tool (takes you to the OT page on the Science Portal)
  - OT Phase I Quickstart (A Quick Start Guide for using the Observing Tool)
  - OT User Manual (Describes how to use the Observing Tool for preparing ALMA proposals)
  - OT Reference Manual (An in-depth description of the Observing Tool)
  - Video Tutorials on how to use the Observing Tool
  - Known OT Issues (for those instances when OT problems are encountered)
- Guides to the ALMA Regional Centers**  
The ALMA Regional Centers provide user support and host special activities related to their respective regions. Their functions are described in the [Guide to:](#)
  - Guide to the East-Asian ARC
  - Guide to the European ARC
  - Guide to the North American ARC
- ALMA Sensitivity Calculator (ASC)**  
The ALMA Sensitivity Calculator (ASC) will calculate the necessary integration times for a given sensitivity, or vice versa, for your ALMA observing project. To run the calculator you need the Java Plug-in installed.
  - The ALMA Sensitivity Calculator tool
  - Sensitivity Calculator Guide (Introduction and help in using the ASC)
- CASA**  
The Common Astronomy Software Applications (CASA) package, is developed with the primary goal of supporting the data post-processing needs of the next generation of radio astronomical telescopes such as ALMA and ESO's VLBA. The package can process both interferometric and single dish data. CASA is designed to support both the data reduction process and the data analysis part. For ALMA, users the data analysis part is likely to be the most valuable part as ALMA data will be pre-processed before delivery to the user. CASA is maintained by the National Radio Astronomy Observatory (NRAO).
  - CASA Home Page (contains links to all relevant CASA documents, tips & tools, download and installation)
  - Current CASA release
  - CASA Guides
- CASA Simulator**  
The Common Astronomy Software Application (CASA) allows user to simulate interferometric observations, including the ALMA observatory. The simulations consider the configuration of the ALMA array, the receiver specifics and atmospheric conditions. It allows the user a great deal of control over both the input and output parameters. The CASA simulator can be of great help when planning a proposal for ALMA. The CASA Simulator and associated documentation is maintained by NRAO.
  - CASA Simulator



# Science Portal

Documents & Tools

Sensitivity Calculator

Proposers Guide,  
Technical Handbook

Observing Tool  
“Quickstart” guide  
& videos

CASA and CASA-  
based observing  
simulators

The screenshot shows the ALMA Science Portal's 'Documents & Tools' page. The page is titled 'Summary of documents and tools available for ALMA' and lists several key resources:

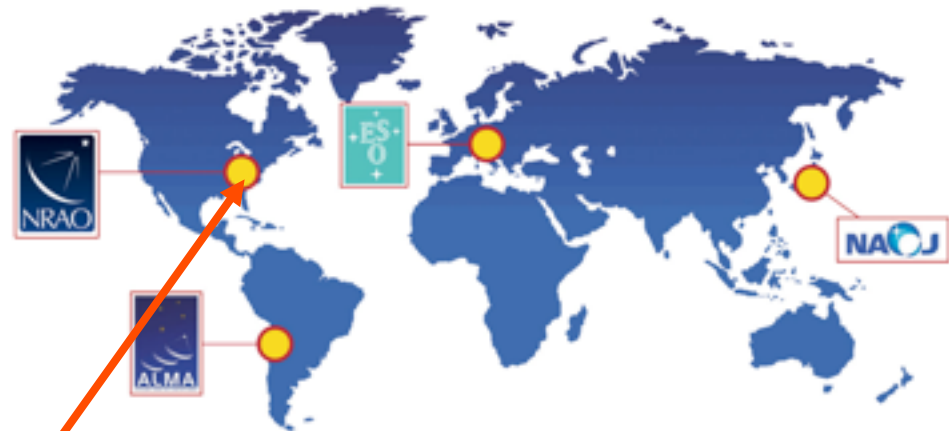
- Call for Proposals**: Documentation supporting the ALMA Call for Proposals for Cycle 0, including the Proposers Guide, Technical Handbook, and Early Science Primer.
- Observing Tool (OT)**: A Java application for preparing and submitting ALMA Phase I proposals, with a 'Quickstart' guide and video tutorials.
- Guides to the ALMA Regional Centers**: Guides for the East-Asian, European, and North-American ARC.
- ALMA Sensitivity Calculator (ASC)**: A tool for calculating integration times for a given project.
- CASA**: Common Astronomy Software Applications, used for data reduction and simulation.
- CASA Simulator**: A tool for simulating interferometric observations.

Red arrows from external text labels point to these sections: 'Proposers Guide, Technical Handbook' points to the Call for Proposals section; 'Observing Tool "Quickstart" guide & videos' points to the Observing Tool section; 'CASA and CASA-based observing simulators' points to the CASA and CASA Simulator sections; and 'Sensitivity Calculator' points to the ASC section. A 'Documents & Tools' label also has an arrow pointing to the 'Documents & Tools' link in the left sidebar.



# Science Support

- Three ALMA Regional Centers: ARCs
  - NA: Charlottesville, VA, USA
  - EU: Garching, Germany
  - EA: Mitaka, Japan
- North American ARC: US - Canada
- **North American ALMA Science Center (NAASC)** encompasses NA ARC and includes partnership with Taiwan



NAASC in Charlottesville, VA



- NAASC: One-stop shopping for:**
- Proposal help and submission
  - Observation preparation (Phase 2)
  - Data archive
  - Data processing
  - Face-to-face visitor support
  - Workshops and tutorials
  - Community outreach

# NRAO User Support

<https://almascience.nrao.edu>

# ALMA



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ALMA



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ALMA

Support Center » Knowledgebase

Knowledgebase Categories

Knowledgebase articles are categorized. Please select which category you would like to browse. You can also search the knowledgebase using the search field beside this text.

- General ALMA Queries (7)
  - What do I do if I forgot my password or username?
  - Can I submit a ticket in Japanese?
  - » more topics
- Early Science - Cycle 0 (20)
  - When I submit proposals in cycle 0, to which region will the time be charged?
  - » more topics
- Helpdesk (2)
  - Why do I see a "Login" screen within the helpdesk when I already logged in via the ALMA User Portal?
  - Who answers my helpdesk ticket?
  - » more topics
- Science Portal (4)
  - I have a professional affiliation with more than one ALMA region. How do I register so I can submit proposals with different affiliations?
  - What is the "Preferred ARC" entry on the registration page?
  - » more topics

How do I use the helpdesk?

- Log In
  - Login to submit a ticket: (You will first need to register with the ALMA Science Portal)
  - Log In
- Main Categories
  - General ALMA Queries (7)
  - Early Science - Cycle 0 (20)
  - Helpdesk (2)
  - Science Portal (4)
  - Science Verification (1)
  - Documentation (2)
  - Simulators (5)
  - Splatalogue (1)

Home

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ALMA for the Public

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The Atacama Large Millimeter Array (ALMA) completed in 2013 is a compact array of 66 radio telescopes. Construction of the 16 antennas in the North American region is under way.

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ALMA Helpdesk –

- ▶ Includes self-help capability
- ▶ Staffed world-wide

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# Future Capabilities of ALMA



- $>3x$  ( $>1.5x$ ) better sensitivity with 50 x 12m antennas in main array compared to Cycle 0 (Cycle 1)
  - Fantastic “snapshot” uv-coverage (1225 baselines)
  - Imaging fidelity  $\sim 10x$  better!
- Higher angular resolution: baselines  $\sim 15\text{km}$ , matched beams in all bands
- Better imaging of resolved objects and mosaics
  - TPA: 4 x 12m antennas with subreflector nutators
  - ACA: Compact configuration 12 x 7m antennas
  - “On-the-Fly” mosaics: quickly cover larger areas of sky

# Future Capabilities of ALMA



- More receiver bands: 4, 8, 10 (2mm, 0.7mm, 0.35mm)
- Polarization: magnetic fields and very high dynamical range imaging
- ALMA Development Program
  - mm VLBI
  - More receiver bands
  - Higher data rates

# Summary

- Amazing scientific promise of ALMA
- Steady progress in construction: 26 antennas now at high site
  - Already more collecting area and spectral coverage than current arrays
- Proposal submission for Cycle 1 in 1<sup>st</sup> half of 2012
- NAASC is your One-Stop shop for community support

Info common  
across project



<https://almascience.nrao.edu/>

NAASC specific  
programs



<https://science.nrao.edu/facilities/alma>