Italian ALMA Regional Center
INAF-Istituto di Radioastronomia (Bologna)
Tutorials, April-May 2011
ALMA basics

ALMA Early Science

Hints to use the ALMA tools

Support for ALMA users
ALMA numbers

- The Atacama Large Millimeter Array is a **mm-submm reconfigurable interferometer**
- Under construction on the Chajnantor plain (5000m, Chile)
- Frequency range: **10 bands between 30-900 GHz** (0.3-10 mm)
- Antennas: **50x12m main array** + **(12x7m + 4x12m) ACA**

**World wide collaboration:**
Europe: ESO (14 countries),
North America: NRAO (USA, Canada),
East Asia: NAOJ (Japan, Taiwan),
Chile
- Contributors share the observing time
ALMA numbers

- The Atacama Large Millimeter Array is a **mm-submm reconfigurable** interferometer
- Located on the Chajinantor plain (5000m, Chile)
- Frequency range: **10 bands between 30-900 GHz** (0.3-10 mm)
- Antennas: 50x12m main array + (12x7m + 4x12m) ACA
- Baselines length: 15m ->150m-16km + 9m->50m
- Bandwidth: 2 GHz x 4 basebands for each of 2 polarisations
- **70 correlator modes**: 31MHz-2GHz / 8192 ch / single, dual, full polarisation product
- **Mosaic capability**
Interferometry in a nutshell

An interferometer reconstructs an image of the sky at fixed spatial scales (i.e. measures single points in the Fourier domain) corresponding to the projection of the baselines on the sky.

**Imaging quality depends on the Fourier space coverage**, i.e. on the number of baselines ($N(N-1)/2$). 
**Resolution depends on the baseline length.**

**Sensitivity depends on effective collecting area, integration time, bandwidth.**

**Water vapour effects get worse as the frequency increases.**

Noise in the image

$$\sigma_{\text{image}} = \frac{k_BT_{\text{sys}}}{AN} \sqrt{\frac{2}{t \Delta \nu \ n_{\text{pol}} N(N-1)}}$$

Angular resolution

$$\theta = 1.33 \frac{\lambda}{b_{\text{maj}} \Delta \theta}$$
ALMA numbers

Dry site, low pwv, low Tsys, high sensitivity also at submm frequencies

>6500 sqm of effective area and 1225 baselines for the 12m array
+ Short spacings with ACA
Excellent instantaneous uv coverage & high sensitivity
<0.05 mJy @100 GHz in 1 hr

Up to 16 km baselines, subarcsec resolution
0.2” x (300/freq_GHz)x(1km/max_baseline)
40 mas @ 100 GHz,
5 mas @ 900 GHz
FOV 12m array: 20.3”/(300/freq_GHz)

Flexibility in spectral and spatial studies

\[
\sigma_{\text{image}} = \frac{k_b T_{\text{sys}}}{A \eta} \sqrt{\frac{2}{t \Delta v n_{\text{pol}} N(N-1)}}
\]

\[
\theta = 1.33 \frac{\lambda}{b_{\text{max}}}
\]

Noise in the image

Angular resolution
ALMA reconfiguration

Antenna transporter

Antenna stations at 5000m
ALMA organization

- 3 sites in Chile
  - AOS: ALMA operations site (5000 m)
    - Antennas, correlator
  - OSF: Operations support facility (3000 m)
    - Labs, antenna assembly and maintenance
    - Operators, astronomers
  - SCO: Santiago central office
    - JAO (Joint ALMA observatory)
      - Calls for proposals
      - Running ALMA
      - Data reduction pipeline
      - Quality assessment
  - Archive
- ALMA Regional Centers
ALMA receivers

Heterodyne Receiver sensitive to Upper and Lower Side Bands (USB and LSB). Sidebands are mapped to a lower frequency band by mixing the sky signal with a Local Oscillator (LO). Varying LO1 changes the sidebands position.

\[ v_{RF} = v_{LO1} \pm v_{IF} \]

ALMA receivers are
- 2SB (separated in the receiver):
  - Bands 3, 4, 5, 7, 8 sidebands 4 GHz wide separated by 8 GHz
  - Band 6 sidebands 5 GHz wide separated by 10 GHz
- DSB (separated in the correlator):
  - Bands 9, 10 sidebands 8 GHz wide separated by 8 GHz
**ALMA frequency setup**

**Band 3:**
2 sidebands to see target lines

**Band 6:**
- 2 sidebands for 2SB continuum
- 5-10GHz separation allows 13CO and 12CO

**Band 9:**
- DSB continuum
The 4 basebands can be setup independently.

Highly flexible correlator: >70 modes

- ALMA correlator
- 8GHz x 2pol
- 8GHz x 2pol
- 8GHz x 2pol
- 8GHz for 2pol

N antennas

1 quadrant = 1 baseband = 2GHz

- 8192 channels
- 1,2 or 4 polarisations
- Spectral window: 31MHz-2GHz

INPUT from front ends

CORRELATOR split in 4 quadrants

OUTPUT from each baseband

...
ALMA spectral windows setup

2SB:
- 2 basebands per sideband

2SB:
- 3 basebands per sideband
  - NOT ALLOWED

2SB:
- 4 basebands per sideband

DSB:
- 3 basebands per sideband
  - ALLOWED
ALMA frequency settings summary

Select the band (i.e. choose the receiver)

Fix LO1 to define the 2 sidebands

Fix LO2 to define the 4 basebands

Chose your polarisation and spectral resolution within each baseband

1 pol: up to 8192 channels (=resolution elements)
2 pol: up to 4096 channels
Full stokes: up to 2048 channels
ALMA correlator modes

Two kinds of operation

- **Time Division Mode (TMD)**
  - Pseudo-continuum/wide spectral line
  - SPW always 2-GHz wide with 64-256 channels

- **Frequency Division Mode (FMD)**
  - High-resolution spectral line
  - SPW can be 58.6-1875 MHz wide with up to 8192 channels

### Correlator Modes for Early Science Cycle 0, dual Polarization

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Channels</th>
<th>Channels x Pol</th>
<th>Resolution</th>
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<tr>
<td>1875</td>
<td>128</td>
<td>3840 x Pol</td>
<td>488 kHz</td>
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<tr>
<td>938</td>
<td></td>
<td></td>
<td>244 kHz</td>
</tr>
<tr>
<td>469</td>
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<td>122 kHz</td>
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<td>234</td>
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<td>30.5 kHz</td>
</tr>
<tr>
<td>58.6</td>
<td></td>
<td></td>
<td>15 kHz</td>
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**TMD**

**FMD**
ALMA correlator summary

- 4 independent basebands
- ~70 modes:
  - 2 GHz to 31 MHz bandwidth / 8192 channels / 1,2 or 4 pol products
  - Varying sampling options (better sensitivity with degraded resolution)
  - Continuum mode
- Possibility to observe many spectral windows/baseband (with same or different resolution/width, polarisation properties...
ALMA calibration

Phase calibration
- Bright unresolved sources (mostly quasars from AT20G, Planck ...)
- Fast switching on calibrators within 2° every few min
- Water vapour radiometry (emission at 183GHz atmospheric line, deduce phase fluctuations on 1s timescale)
- Positional accuracy <1/10 synthesized beam-width

Flux density scale (primary)
- Planets/moons can be used (Neptune, Titan)
- Asteroids, Radio stars, quasars depends on quality of models, frequency, configuration...
- Initial expected accuracy <5% B3, <10% B6-7, <20% B9

Bandpass calibration
- Bright unresolved sources (mostly quasars from Planck catalogues)

Polarisation calibration
- Well known polarized or unpolarized sources (edges of planets/moons?). Still under characterization.
Science Verification
- On-going to observe known sources to validate the output of ALMA
- Data made public (in June): not for science

Early Science
- 31 March: call for proposals and ALMA Science Portal opening
- 29 April: deadline for notice of intent (not compulsory): 601 arrived!!!
- 1 June: opening of the archive for proposal submission
- 30 June: proposal submission deadline
- 30 September 2011 - 30 June 2012: ES Phase 0 observations (500-700 h)

http://almascience.eso.org/call-for-proposals
First tests of science with ALMA

High resolution and sensitivity imaging
In total power and line.

This shows the well-known spiral NGC253, with an optical image of the whole galaxy on the left (credit: ESO). The ALMA test images show dense clouds of gas in the central regions of the galaxy: (middle) the CO J = 2-1 line at 230 GHz and (right) the continuum and CO J = 6-5 line at 690 GHz.

As a test of ALMA’s ability to observe broad spectral lines, we observed the quasar BRI 0952-0115, which is at a redshift of z = 4.43. The object is again unresolved on short baselines, but the 168 micron line from ionized carbon is clearly detected in the spectrum, which is impressive given that this observation took only one hour in total.

ALMA 8 antennas hw/sw tests mid 2010

High resolution spectroscopy

An example of ALMA’s potential as a spectroscopic instrument: on the left is the map of the molecular “hot core” G34.26+0.15, which is unresolved with the short baselines that we are presently using, so the “image” is not very interesting whereas a section of the spectrum near 100 GHz shows a “forest” of molecular lines. A few of the chemical species that are responsible for the emission lines are identified on the plot.
**Frequency range:**

- Full array: 10 bands 30-900 GHz
- Early Science: 4 bands (3, 6, 7, 9)

**Antennas:**

- Full array: 50x12m + ACA
- Early Science: 16x12m (no ACA)

**Sensitivity:**

- Full array: 0.15 mJy in 1 min at 230 GHz
- Early Science: 0.5 mJy in 1 min at 230 GHz

**Max baseline:**

- Full array: 150m-16km
- Early Science: 2 configs: 18-125m, 36-400m

**Resolution:**

- Full array: 20 mas @ 230 GHz, 70 correlator modes
- Early Science: 1000 mas @ 230 GHz, 14 correlator modes

**Mosaic capability**

- Full array: Limited mosaic capabilities
- Early Science: Pipeline reduction in Chile, Reduction @ ARCs

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<th>Lower frequency [GHz]</th>
<th>Upper frequency [GHz]</th>
<th>Type</th>
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<tr>
<td>3</td>
<td>84</td>
<td>116</td>
<td>2SB</td>
</tr>
<tr>
<td>6</td>
<td>211</td>
<td>275</td>
<td>2SB</td>
</tr>
<tr>
<td>7</td>
<td>275</td>
<td>373</td>
<td>2SB</td>
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<tr>
<td>9</td>
<td>602</td>
<td>720</td>
<td>DSB</td>
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<th>Frequency [GHz]</th>
<th>Angular Resolution [&quot;]</th>
<th>Maximum Scale [&quot;]</th>
<th>T_{bc} [mK]</th>
<th>Flux [mJy]</th>
<th>T_{bl} [K]</th>
<th>Field of View [&quot;]</th>
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<td>5.3</td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>345</td>
<td>1.55</td>
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<td>1.8</td>
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<td>0.043</td>
<td>18</td>
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<td>9</td>
<td>675</td>
<td>0.80</td>
<td>3</td>
<td>15</td>
<td>3.2</td>
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<td>9</td>
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**Properties of the Compact Configuration (baselines of ~18 m to ~125 m)**

**Properties of the Extended Configuration (baselines of ~36 m to ~400 m)**
ALMA-ES correlator summary

- 4 independent basebands
- Same mode for all the basebands
- 70 modes:
  - 14 modes
  - 2 GHz to 31 MHz bandwidth / 8192 channels / 1,2 or 4 pol products
  - Varying sampling options (better sensitivity with degraded resolution)
  - Continuum mode
- Possibility to observe many spectral windows/baseband (with same or different resolution/width, polarisation properties...)
  - Only one spectral window per baseband
ALMA Tools
ALMA will be dynamically scheduled in service mode

Some tools: the Science Portal and the Helpdesk (SP)  
the Observing Tool (OT)  
the Splatalogue  
the Common Astronomy Software Application (CASA)  
the Observation Support Tool (OST)

Thought to be suited both for experienced and non experienced observers.

Care about the limitations in resolution and sensitivity for the ES!  
ALMA ES is ok for few hours, limited scope projects!  
Furthermore, experience in mm interferometry is needed among investigators because data won't pass through the pipeline  
Calibration quality is being assessed!
ALMA project checklist

Have a good idea!
Estimate required configuration
Write the proposal idea in pdf docs
(max 5 page)
Register to the Science Portal
PHASE I – Proposal submission
TAC evaluation
PHASE II – Observing program
submission for accepted proposals
Observations
Data reduction and analysis

(CASA, Splatalogue, OST, OT)
(SP)
(OT, SP, Helpdesk)
(OT, SP, Helpdesk)
(CASA)
ALMA simulations (Observation Support Tool)

http://almaost.jb.man.ac.uk/

Submit a request for a full simulation of ALMA capabilities for your target
Receive the results via e-mail
ALMA simulations (CASA simdata)

Simulation of NGC3627 @ z=0.1

Early Science
Baseline 250m

Early Science
Baseline 450m

Full array
The Science Goal: Sensitivity Calculator

http://almascience.eso.org/call-for-proposals/sensitivity-calculator

Additional information is available to users on the valid range for each parameter by hovering your mouse pointer over each field in the calculator applet (this does not currently work in Safari). The ALMA Sensitivity Calculator Guide gives a brief description of how the ASC works.

The calculator defaults to the number of antennas available during Cycle 0, but the user can select a higher number of antennas in order to compare the capability in future cycles. The resulting integration times refer only to the on-source time and do not take any kind of overheads into account. Furthermore, the ASC calculates the integration time/sensitivity for a single pointing. The case of pointed mosaics is discussed in the Technical Guide.

A Java Plug-in must be installed in order to run the calculator. If the calculator is not displayed, then it is likely that this plug-in is not installed. Instructions for installing the plug-in may vary, depending on the browser and operating system used. A Plug-in compatible with the Java Development Kit version 1.5 or 1.6 (e.g. Java 5 or 6) is required. Users should contact their local IT department for installation help if necessary.
OT is a java-based client program, requires Java 1.6 (currently), runs on Linux (various distr.), MacOS (10.5-10.6), Windows (>XP).

The graphic interface allows one to get help/feedback and hints even with small knowledge of the system.
The project properties

Proposal Information

- **Proposal Title**: My new idea
- **Proposal Cycle**: 9999.5
- **Abstract** (max. 300 words): My abstract goes here!
- **Scientific Category**
  - Cosmology and the High Redshift Universe
  - Galactic Nuclei
  - Stellar Evolution/the Sun and the Solar System
  - ISM/Astrochemistry/Star Formation/protoplanetary disks/exoplanets

Proposal Type
The project properties
The Science Goal concept

The OT divides the observing info of a project into “Science Goals”

A Science Goals is a container of:
- an optional description of the goal
- the Field setup to define the observing targets
- the Calibration setup
- the spectral setup to define the frequency range and correlator configuration
- the Control and Performance parameters to define the sensitivity and resolution goals

Divide your targets into SG according to telescope configurations, sky area…
i.e. more than one source can be in a SG, but only one instrumental configuration; more than one SG can be in a proposal
The Science Goal: Template Library

A selection of hot science topics for science goal templates is on-board the OT.

Possibility to drag and copy the full science goal!!!
The Target setup
The Spatial visualizer

Always accessible through the tag menu.
Resolves known objects.
Add images from databases.
Overlay mosaic pattern and details.
Mosaicking

Single field pointings

Mosaic (up to 50 pointings in ES!)
The Calibration setup in the observing tool

"...We STRONGLY suggest that you leave this choice at 'System-defined'..." at least for the ES Phase 0

If user-defined calibration is necessary, care to justify it in the proposal!!!
The Spectral properties
Search for all the lines that might fall in your observing region:
It might be enough to add a spectral window to improve your results!
(but care to justify it in the proposal...)

The Spectral visualizer
The control and performances panel
The Science Goal: Summary & tools

**Field setup:** Add as many targets as you want, in the same sky region
OT resolves for known objects
User ephemeris for moving bodies (comets, asteroids, TNOs)
Access online surveys for imaging
Use the interactive panel to draw on the image of your region
(or to define your mosaic)

**Calibration setup:** Fully automatic (easy!)
User setup with access to calibrator catalogues/queries

**Spectral setup:** Central frequency average for continuum
Hidden LO and correlator as possible (to make it easy)
Splatalogue available to identify lines
Limited configurations available for ES (up to 4 sp.windows)

**Performance control:** Timing is based on sensitivity goals (or viceversa)
Resolution determines the configuration
(no need to know where antennas are)
Low number of antennas and short baseline in ES
The summary, validation and submission

Validation at any stage
Save at any stage on your PC
Archive open for submission on 01 June 2011
The summary, validation and submission

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<td>Marcella Massardi</td>
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<td>SCIENCE CATEGORY:</td>
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<tr>
<td>CO-INVESTIGATOR NAME(S):</td>
<td>Viviana Cassacca</td>
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**ABSTRACT**

*Here is my abstract...*

**REPRESENTATIVESCIENCEGOALS(UPTO10STSS)**

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<th>POS.(J2000.0)</th>
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Total # Science Goals: 1

**SCHEDULINGTIMECONSTRAINTS**

(e.g. Co-ordinated observations already scheduled)

NONE

**CONTACT INFORMATION**

<table>
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<tr>
<th>TITLE:</th>
<th>NAME: Marcella Massardi</th>
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**INSTITUTE/DEPT.:**

NA

**ADDRESS:**

EU

Modification/withdrawal of submitted proposals before the deadline (30 June 2011 for ES P0)

A further validation is performed at the submission stage to guarantee the correctness of the projects.
Proposals will be reviewed by an international proposal review committee. There will at least one Review Panel for each of the main themes:
- Cosmology and the High Redshift Universe
- Galaxies and Galactic Nuclei
- ISM, Star Formation/protoplanetary Disks and their Astrochemistry,
- Exoplanets
- Stellar Evolution, the Sun and the Solar System

The ranked proposals from the different panels and sub-panels will be merged into a single ranked list in the ALMA Proposal Review Committee (APRC) and assigned a letter grade A through D:
- A the proposal will be carried over to the following cycle if it is not finished
- B the proposal should be finished during the current cycle but will not be carried over to the next cycle.
- C are 'filler' programs observed when no A or B can be scheduled
- D proposals will not be observed.
PHASE II observing programs

Investigators will be notified of the result of the ALMA Proposal Review process via email and successful investigators will be invited to submit a detailed observing plan. **The ALMA Observing Tool (OT) is used to prepare individual Scheduling Blocks** (SBs, about 30min for weather reasons)

The best SBs at any moment will be observed (science, weather, project status)

These will be used by the ALMA Scheduling Software to ensure that the observations are carried out under the required weather conditions. The ALMA Regional Centers (ARC) will provide support to investigators in the Phase II process.

Once the Phase II preparation is finished the Scheduling Blocks will be submitted to the ALMA site and scheduled according to rank and requested observing conditions. Investigators will be able to track the status of their project with the ALMA Project Tracker.
...and then?

For the ALMA full array a pipeline will be operating
PIs will receive fully reduced images+raw data+scripts

For Early Science the pipeline is being assessed
“...ALMA staff will conduct quality assurance on ALMA data...”
PIs will receive raw data+ quality assessment scripts

Proposer experience in radio-mm interferometry is required to reduce Early Science data.
Support can be requested to the ARCs.

CASA scripting helps in calibration & reduction.

*Care for the huge amount of data!!!*
Getting help with ALMA
Contextual Help in the overview panel

Clickable instruction for each step


OT manual, cookbook, guide available on-board the OT (F1 key) and/or on-line
The Helpdesk

Registered users can submit questions or help requests (tickets) for problems with ALMA products or procedures. Urgent issues with the proposal submission process have a dedicated category. The tickets enrich the knowledge database, where the HD can search for help.

https://alma-help.nrao.edu/
Submit a Ticket

If you can’t find a solution to your problem in our knowledgebase, you can fill in the fields below with as much detailed information as possible and send it to our agents.

General Information

Priority: Default

General

Sub-Categories:
- Science Portal/Registration
- Documentation
- Webpages
- Proposal reviews and assessment (science and technical)
- Project tracking
- Other

Message Details

Subject: adding a spectral window

Hi, I’m refining my proposal and want to add a spectral window to the LSB...

Knowledgebase suggestions

The following articles from our knowledgebase might be relevant to what you’re looking for. Please take the time to read them before submitting your ticket.

- I want to observe 4 lines/bandpasses, 3 in one sideband and 1 in the other. Why can I not set this up in the OT? (Relevance: 100.00%)
- What do I do if I can’t get the OT to work? (Relevance: 49.58%)
- When is the Cycle 0 proposal deadline and observing period?
The ALMA Regional Centers (ARC)

- **Interface between JAO and users**
  - 1 ARC per Partner:
    - NRAO for North America
    - NAOJ for East Asia
    - ESO for Europe

- **Operation support**
  - Archive replication
  - Astronomer on duty
  - Software tools

- **User support**
  - Community formation and outreach (schools, workshops, tutorials, ...)
  - Phase 1 (proposal preparation)
  - Phase 2 (scheduling block preparation)
  - Data analysis
  - Archive mining
The European ARC

- ESO European ARC distributed over a 7-nodes network
- ARC center at ESO: core tasks
  - Proposal handling
  - Archive
  - Data product support (ALMA data and software)
  - Helpdesk

- **ARC nodes:**
  - Face to face support
  - User formation
  - Advanced tools
The Italian ARC node

• Hosted by the IRA in Bologna
  – ARC Manager: Jan Brand
  – contribution from 6 members of IRA permanent staff
  – 1 tenured position (Massardi)
  – 4 Post-Docs (Casasola, Mignano, Paladino, Rossetti)
  – 1 system manager (Bedosti)
  – 1 ESO ALMA co-funded fellow (Boissier)

• User support
  – Face to face (ALMA software)
  – Polarimetry, mosaicing, GRIDDING computations

• Community formation
  – In 2010: community day and CASA tutorials
  – In 2011: tutorials or ALMA ES
  – 13-17 June 2011: Astrochemistry with ALMA school in Bologna
For your proposals, data reduction, ALMA related stuff
don’t struggle on your computer:
contact us and/or organize your visit to IRA-ARC node

To ask f2f help send a ticket to the central helpdesk
indicating your “favourite” ARC node

- 2 visitor stations available
- 1 ARC node member dedicated to each visitor
- 10 TB disk space available during your visit + 1 month for download
- No fundings available for visitors

Helpdesk: https://alma-help.nrao.edu/
Web: http://www.alma.inaf.it
### Request for a f2f visit!!!

Submit a Ticket

If you can’t find a solution to your problem in our knowledgebase, you can fill in the fields below with as much detailed information as possible and send it to our agents.

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Visit our site!!!
Web: http://www.alma.inaf.it

The Italian ARC is hosted by the Istituto di Radioastronomia in Bologna and is one of the seven nodes that constitute the European network that will provide technical and scientific support to ALMA users. The nodes will be operating in close collaboration with each other and with the central node at ESO, Garching. Each node contributes its own specific expertise, in order to ensure that maximum advantage is taken of the European competences in the field of mm-astronomy and interferometry.

Our ARC node staff will support the ALMA users in all the steps of their projects, by helping in

- using the ALMA tools for proposal preparation and submission
- improving the observing strategy
- tracking the project status
- reducing data with CASA
- analyzing data in continuum, spectral lines, mosaic, polarization
- archive mining
- handling ALMA large amount of data (also through GRID)

What's on

ASTROCHEMISTRY WITH ALMA

The Italian ALMA Regional Centre and the Osservatorio Astrofisico di Catania organize a Training School "Astrochemistry with ALMA".

The School is funded by the EU through ITN LASSIE Network and COST Action CM0805.

Date: 13 - 17 June 2011
Venue: Research Campus, CNR Bologna

The School will consist of general introductory lectures which will present the ALMA project and its potential impact on astrochemistry.

The focus will be on chemistry in star forming regions, in envelopes of evolved stars, and in comets.

The School is open to students of all backgrounds (experimental, observational, theoretical) and is meant to provide researchers not actively involved in interferometry with a basic knowledge for a successful use of ALMA.

Last updated: Wednesday, 20 April 2011
Summary

• **ALMA is a unique instrument in the (sub-)mm (0.3 to 10 mm) range**
  
  – Unequaled sensitivity
    
    • Large collecting area (7200 m²), excellent dry site (5000 m altitude)
    
    • e.g. 6 uJy in 6h @ 230 GHz
  
  – Great imaging capabilities
    
    • 50 antennas +ACA, variable configuration
    
    • High resolution (15km = 40 mas @ 100 Ghz, 5 mas @ 900GHz)
  
  – Flexible spectral configuration
  
  – Pipeline reduced data

• **Early Science proposal submission deadline on 30th of June**
  
  (care for the limited capabilities !!!)
  
  – 16 antennas, baselines up to 450m, reduced number of spectral modes

• **Tools are designed to help the experienced AND non experienced user to use ALMA.**
  
  – Access to the ALMA world through the Science Portal and the ALMA Observing Tool
Enjoy your ALMA proposals  !!!!!

Contact the Helpdesk and your ARC node for support

Web: http://www.alma.inaf.it
Email: help-desk@ira.inaf.it
Helpdesk: https://alma-help.nrao.edu/

Useful links:
ALMA SP: http://almascience.org/
ALMA PRIMER FOR ES: http://almatelescope.ca/ALMAPrimer.pdf
ALMA CfP: http://almascience.eso.org/call-for-proposals