ALMA

Frédéric Gueth, IRAM Grenoble
ALMA Science Advisory Committee
IRAM node of the ALMA Regional Center
• The ALMA project
  • ALMA construction: status as of Sept. 2010
  • ALMA Operations & Early Science
  • The IRAM ARC node
ALMA

• **Atacama Large Millimeter/Submillimeter Array**

• World-wide collaboration between Europe (**ESO**) – North America (USA, Canada, Taiwan) – Eastern Asia (Japan, Taiwan) – Chile

  • Main array: 50 X 12 m antennas
  • ALMA Compact Array (ACA): 4x12m + 12x7m
  • Frequency range: 30—900 GHz (0.3—10 mm)
  • 16 km max. baseline (<10 mas ang. resolution)
  • ALMA is a spectro-imager instrument providing data cubes
Level 0 requirements

1. The ability to detect spectral line emission from CO or CI in a normal galaxy like the Milky Way at a redshift of 3, in less than 24 hours of observation.

2. The ability to image the gas kinematics in protostars and protoplanetary disks around young Sun-like stars at a distance of 150 pc.

3. Provide precise images at 0.1 arcsec resolution.
IRAM
Atmospheric transmission at Chajnantor, pwv = 0.5 mm

Freq. coverage: 30—900 GHz
Bandwidth: 8 GHz x 2 polarizations

North America
Band 3 (84-116 GHz)
Band 6 (211-275 GHz)

Europe
Band 7 (275-373 GHz)
Band 9 (602-720 GHz)

Japan
Band 4 (125-163 GHz)
Band 8 (385-500 GHz)
Band 10 (787-950 GHz)
Band 7 @ IRAM

All bands installed in one single cryostat (Front-End integration Centers)
Correlator

- The ALMA correlator provides ~70 modes
  - Process 8 GHz bandwidth x 2 polarizations
  - One, two, or four polarization products
  - Various sampling options

- Usual **tradeoff bandwidth vs. resolution**
  - 4x2 GHz bandwidth @ 244 kHz resolution
  - 4x32 MHz bandwidth @ 3.8 kHz resolution
    (0.005 km/s @ 230 GHz)
Imaging

- 50 antennas, 1225 baselines
- ALMA imaging simulateur in GILDAS and CASA

28 different antenna configurations, from compact to ~16 km, continuous reconfiguration
- Angular resolution $\frac{\lambda}{B}$ down to 40 mas (100 GHz), 5 mas (900 GHz)

- **Short spacings: ACA** observations + 4 single-dish antennas

  **Caution: not all projects can have ACA data!**
Configurations ALMA
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UV coverage
Sensitivity

- Collecting area = 7200 m$^2$ (~5x Bure), excellent site
  \[ \text{Ex: rms = 8 \( \mu \)Jy in 6h (8 GHz continuum, 230 GHz)} \]
- Online sensitivity estimator:
  
  http://www.eso.org/projects/alma/science/bin/sensitivity.html

- Point-source sensitivity: gain of ~1 order of magnitude compared to current PdBI
- Resolution: gain of >1 order of magnitude vs. PdBI
- Surface brightness sensitivity: depends on angular resolution
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OSF Site @ 2900 m altitude

San Pedro de Atacama

AOS
OSF Site @ 2900 m altitude

San Pedro de Atacama

Antenna construction areas

Main building: offices, control room, archive, technical labs

AOS
Vertex and Melco antennas
European antenna (AEM)
Antenna surface rms < 25 μm
AOS – ALMA Operation Site (5000 m)
Two antennas interferometry (Nov. 2009)
Three antennas interferometry (Dec. 2009)
The ALMA project
ALMA construction: status as of Sept. 2010
**ALMA Operations & Early Science**
The IRAM ARC node
ALMA Operations

- One call for Proposals per year
- One single Time Allocation Committee for NA+EU+EA
- Service observing
  - PI not involved in the observations
- Dynamic scheduling
  - Best project in the queue determined every SB (hour scale)
  - Depends on weather + configuration + priority + balance between partners
ALMA Operations

- **Calibration and imaging pipeline**
  - Final product = data cube

- **Archive**
  - Raw data + pipeline products
  - Public after 12 months

- **ALMA Regional Centers (ARC)**
  - Scientific operations & user support outside Chile
  - Contact point between users and ALMA
  - Three ARCs
ALMA Regional Center

Astronomers → ARC → JAO → ARC

ARC:
- User formation
- Call for proposals
- Support Phases I & II

JAO:
- Service observing
- Dynamic scheduling
- Calibration + imaging pipeline

ARC:
- Archive
- Helpdesk
- f2f user support
European ARC

Core tasks → ESO Garching
- Call for proposals, Phase I, Phase II
- Basic user support (helpdesk)
- Data product support = delivering data and software
- ALMA archive operations

http://www.eso.org/sci/facilities/alma/arc/

Same services are provided at Charlottesville (NAASC) and Tokyo
European ARC

Additional tasks → ARC nodes
- User formation & community development
- Face-to-face support (core task)
- Special projects (extended archive & data reduction support)
- New developments

Seven ARC nodes in Europe
- INAF Bologna (I)
- Univ. Bonn (D)
- IRAM (F,D,E)
- Leiden Obs. (NL)
- Manchester Obs. (UK)
- Onsala Obs. (S,DK,SF)
- Prague (CZ)

• All nodes open to all European scientists but target own community
  • IRAM → French, German, and Spanish communities
ALMA observing time

- No guaranteed time
- One single TAC for NA+EU+EA
- A world-wide collaboration
  - EU 33.75%, NA 33.75%, EA 22.5%, Chile 10%
  - In ESO: D~21%, F~16%, E~9%
  - In ALMA: D~7%, F~5.5%, E~3%
- Huge competition
ALMA Early Science

**Cycle 0**
- 2011-2012; pression ~ 10

**Cycle 1**
- Deadline July 2012
- Observations in 2013
- Four bands: B3, B6, B7, B9
- 32 antennas
- Baselines up to 1 km
- ACA & SD

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<tr>
<th>ALMA</th>
<th>IRAM</th>
<th>GHz</th>
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<tr>
<td>B3</td>
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**Cycle 2**
- Deadline mid 2013
Fomalhaut,
Boley et al. 2012
Complex molecules in IRAS16293

Jorgensen et al. 2012
AGB star RScl
(Maercker et al. 2012)
ALMA

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ARC node @ IRAM

Why an ARC node at IRAM?

- Strong IRAM involvement in ALMA construction
- Already existing center of expertise in mm interferometry
  - Expertise on pipeline, calibration, imaging, atmospheric phase correction, data analysis...
  - Close link with technical groups
- Plateau de Bure user support → only delta effort
- IRAM users are all potential ALMA users → IRAM community in best possible position to get time on ALMA
ARC node @ IRAM

User formation
- Plateau de Bure
- Visitors
- Schools

Developments
- New algorithms & soft.
- ALMA software

User support
- Helpdesk
- f2f support
ARC node @ IRAM

**User formation**
- Plateau de Bure
- Visitors
- Schools

**Developments**
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- ALMA software

**User support**
- Helpdesk
- f2f support

**Key goal**
f2f support

- Main goal of the ARC node
- Extend PdBI f2f support to ALMA
  - Local contact assigned to each project
  - Use existing infrastructures and procedures
  - Travels to Grenoble will be funded by IRAM (same rules as PdBI)
f2f support

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  - Travels to Grenoble will be funded by IRAM (same rules as PdBI)
  - Must be in place for Early Science = end 2011

http://www.iram-institute.org > ARC Node