

Using ALMA

concepts and tools of science operations,
interaction with and support to the users

Paola Andreani
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Meaning of ALMA Operations and the Joint ALMA Observatory

Science Operations Astronomer's perspective

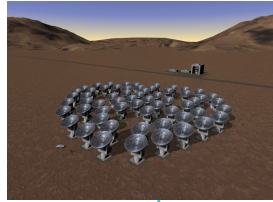
Principles:

- 🍏 Non-experts should be able to use ALMA
- ♣️ Dynamic scheduler to match observing conditions
- ♠️ Reliable and consistent calibration
- ◆ Data public in timely fashion



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ALMA Sites in Chile



**Antenna
Operations
Site (AOS)**

**40 MB/s
(peak)**

**Operation
Support
Facility (OSF)**

**6 MB/s
(average)**

**Santiago Central
Office (SCO)**



Paola Andreani

High-level concepts for Science Operations

- Observations will be done in service observing mode with flexible (dynamic) scheduling.
- Observations 24h/day interrupted by maintenance periods.
- All observations are executed in the form of scheduling blocks (SBs), each of which contains all information necessary to schedule and execute the observations.
- The default output to the astronomer are reliable images, calibrated according to the calibration plan.
- The Joint ALMA Observatory (JAO) is responsible for the data product quality.
- All science and calibration raw data are captured and archived.



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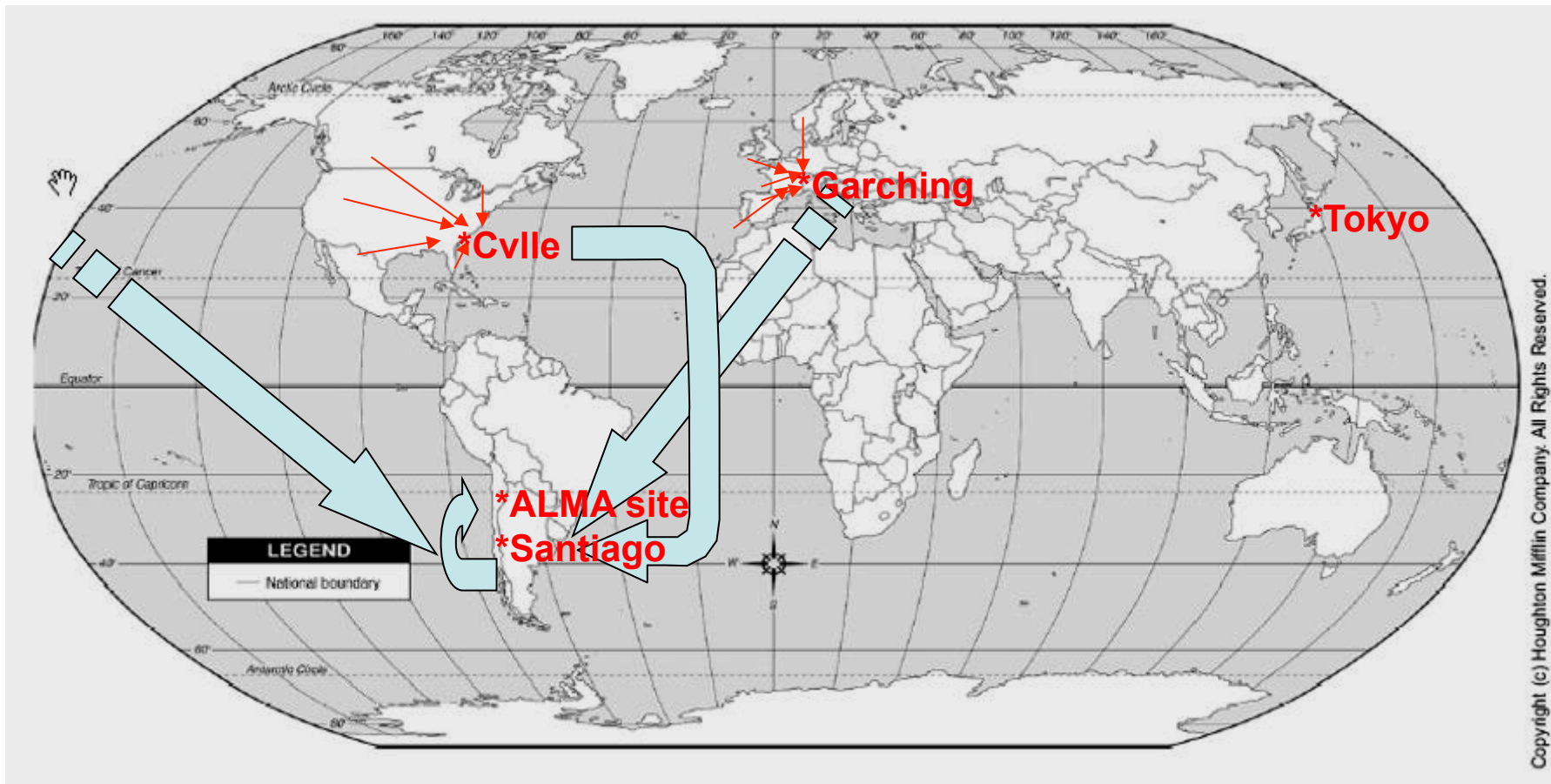
Science Deliverables:

- uv-plane astronomical source and calibration data.
- Processed images, with supporting information on the data processing and quality assurance.
- Off-line data reduction software, including user support for installation and basic usage.
- Software tools for proposal and observation preparation, including user documentation.
- ALMA users manual.

User support:

- Helpdesk
- f2f support

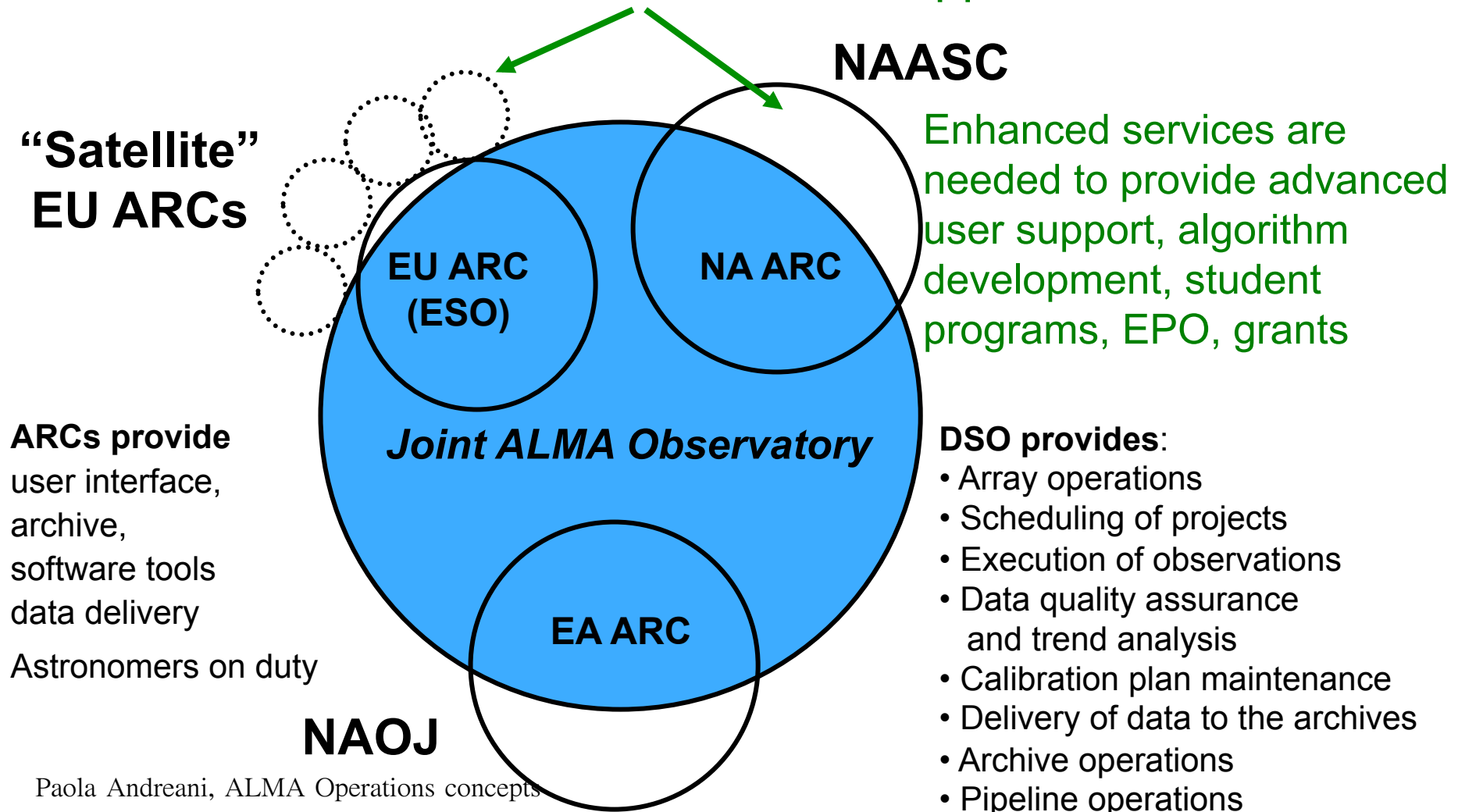
ALMA Science Operations sites OSF, Santiago and the ARCs



The Regional centres

ALMA Operations: Three ALMA Regional Centres - ARCs

Face to face + other user support



Meaning of ALMA Operations

What does science Operations mean?

- **Phase I + II proposals through ARCs**
(time estimator, end-to-end data simulator)
- **Create project (scheduling blocks) to OSF**
- **Data taken in service mode**, dynamic scheduler selects programmes according to science rating weather conditions, array configuration, consistent calibration
- **Pipeline data reduction, quality control, archive**
- **Advanced data reduction at ARCs**

Getting ALMA time

Getting ALMA time

Phase I

❖ Joint ALMA Observatory issues calls for proposals

- Register with the ALMA website
- Prepare a proposal
- user

MAKE A PROPOSAL!

Scientific case

Instrument setup: frequency

rms

❖ A

COO

S/

sc

sp

Program Review Commit

❖ Executives approval





The ALMA observing tool



The screenshot displays the ALMA Observing Tool interface for a project named "NGC 253 CO (1a)". The interface is divided into several panels:

- Project Structure:** A tree view on the left showing the project hierarchy. Key items include "Science Plan", "Science Goal - generated", "Field Setup", "Spectral Setup", "Control Parameters", "Calibration Setup Parameters", "NGC 253-SFI", "NGC 253 hi res", "4 Targets" (including J0050-094, J0120-270, J0051-068, and NGC 253), "Resources", "5 Field Sources" (including Primary: NGC 253), "4 Instrument Setup", "7 Observing Parameters", and "NGC 253 low res".
- Editors:** A central panel showing a large image of the NGC 253 galaxy. A field of view (Fov) is overlaid on the image, showing a cluster of pointing positions. A smaller inset image shows a zoomed-in view of the field.
- Field Source Editor:** A panel on the right providing details for the selected field source. It includes:
 - Fov Parameters:** Frequency used (230.00000), Antenna Diameter (12m selected), and Show Fov(circle) checked.
 - Image Query:** Image Server (Digitized Sky (V)) and Image Size(arcmin) (12).
 - Field Source Editor:** Name (Primary), Source Name (NGC 253), and Source Coordinates (System J2000, RA 00:47:20.973, Dec -25:18:03.17).
 - Reference Position (Offset):** Coordinates 00:47:20.973, -25:18:03.17 J2000.
 - Field Pattern:** Type (point).
 - PointingPattern:** Offset, Offset Unit (arcmin).

At the bottom of the interface, there are tabs for "Spectral", "Spatial", "Forms", and "Catalog". A status bar at the very bottom indicates "Reserved for future use".



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The ALMA Observing tool



- Split Observing Programs in two parts:
- a Phase I Observing Proposal
 - emphasis on the scientific justification of the proposed observations.
- a Phase II Observing Program
 - submitted only if observing time has been granted.
- Set of Scheduling Blocks (SBs)
 - required to drive observing with ALMA.
 - the SB contains a full description of how the science target and the calibration targets are to be observed
- sets of SBs can be combined with a description for the post processing of the data, ultimately resulting in an image.

Getting ALMA time

Phase II

- ❖ Phase I: Proposals are submitted using ALMA Observing Tool
 - **Phase II:** Successful PIs submit observing programme using the Observing Tool
 - Preparation of the scheduling blocks
 - European ARC helps with observation planning and validates observing schedule



The ALMA observing tool



The screenshot displays the ALMA Observing Tool interface. On the left, the 'Project Structure' tree shows a project named 'unnamed project' with a 'Science Plan' containing 'm82 - generated' and 'm82 - SFI'. Under 'm82 - SFI', there are sub-items for 'm82 [12mArray SB]', 'm82 [ACA SB]', and 'm82 Params'. The 'm82 [12mArray SB]' item is expanded, showing '1 Target', 'Resources', '1 Field Source', '1 Instrument Setup', '1 Observing Parameters', and 'm82 Params'. The 'Instrument Setup' item is highlighted in yellow.

The main window is divided into several panels. The top panel, 'Editors', shows 'Receivers & LO Visualisation' with a plot of 'Observed Frequency' from 0 to 1000 MHz. The plot shows several peaks, with a specific peak at 250.000 GHz highlighted. Below this plot are checkboxes for 'Basebands', 'Other Lines', 'BBC Centre Frequencies', 'Receiver Bands', 'Side Bands', and 'Transmission'. The 'BBC Centre Frequencies' and 'Receiver Bands' checkboxes are checked. There are also buttons for 'Reset', 'Pan to Line', and 'Zoom To Band'.

The bottom panel, 'Baseband Visualisation', shows a plot of 'Observed Frequency' from 200 to 280 MHz. A peak at 247.000 GHz is highlighted. Below this plot are checkboxes for 'BBC 1 (U)' and 'BBC 2 (U)'. The 'BBC 1 (U)' checkbox is checked.

On the right side, the 'Spectral Spec' panel shows configuration options for 'Setup for Cont(250.0 GHz)'. It includes fields for 'Rest Frequency' (250.00000 GHz), 'Transition' (Cont(250.0 GHz)), 'Receiver Band' (ALMA_RB_06), 'Receiver Type' (TSB), 'Dynamic Range' (100.0), 'Integration Time' (0.94190 s), and 'Sub Scan Duration' (30.72000 s). There are also checkboxes for 'Total power with square law detectors' and 'Switching' options.

The 'Correlator Configuration' panel shows 'Integration Duration' (1.02400 s) and 'Channel Average Duration' (512.00000). The 'Atmos. Phase Correction Data To Save' is set to 'AP_CORRECTED'. The 'Dump Duration' is 512.00000 ms.

The 'BaseBand Configurations' panel shows 'Setup Preferences' with checkboxes for 'Sideband(s) to prioritise' (USB, LSB) and 'Base band config(s) to prioritise' (BBC 1, BBC 2, BBC 3, BBC 4). The 'BBC 4' checkbox is checked. There are buttons for 'GO' and 'Results'.

Below the 'BaseBand Configurations' panel is a table with the following data:

Name	Center Frequency	Data Product	Sidebands	LO2 Frequency
BB_1	247.000 GHz	CROSS_AND_AUTO	FREQUENCY_OFFSET_REJECTION	8.980 GHz
BB_2	249.000 GHz	CROSS_AND_AUTO	FREQUENCY_OFFSET_REJECTION	10.980 GHz
BB_3	251.000 GHz	CROSS_AND_AUTO	FREQUENCY_OFFSET_REJECTION	12.980 GHz
BB_4	253.000 GHz	CROSS_AND_AUTO	FREQUENCY_OFFSET_REJECTION	14.043 GHz

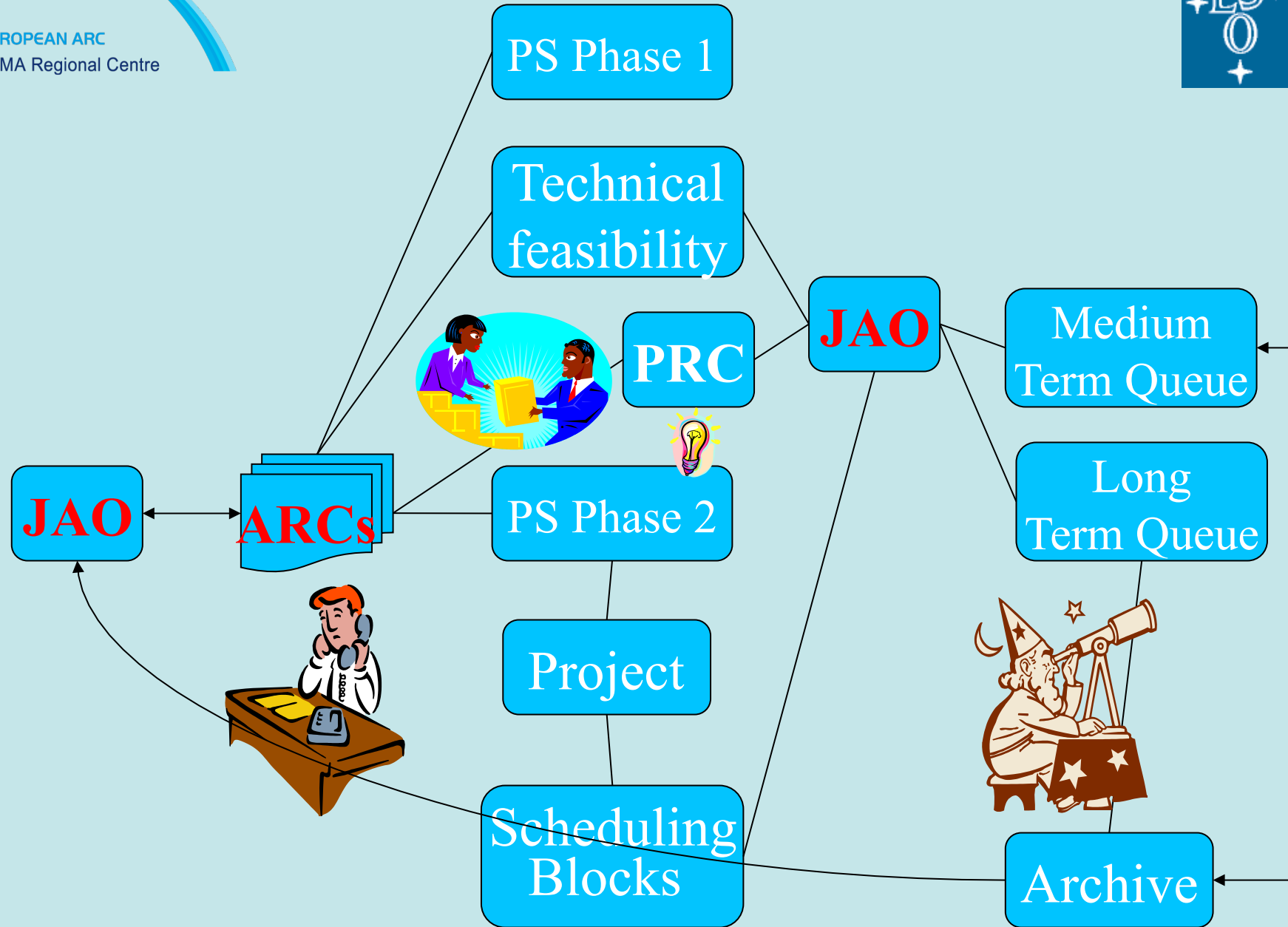
Below the table are buttons for 'Add BaseBand' and 'Delete BaseBand'. The 'Baseband Name' is 'BB_1', 'Center Frequency' is 247.00000 GHz, 'Accumulation Mode' is 'ALMA_NORMAL', and 'Products & Sideband' is 'CROSS_AND_AUTO & FREQUENCY_OFFSET_REJECTION'.

At the bottom of the interface, there is a 'Feedback' table with columns for 'Description', 'Suggestion', and 'Resource'. The table is currently empty. There are also buttons for 'Log', 'Problems', and 'Information'.



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ALMA DATA FLOW

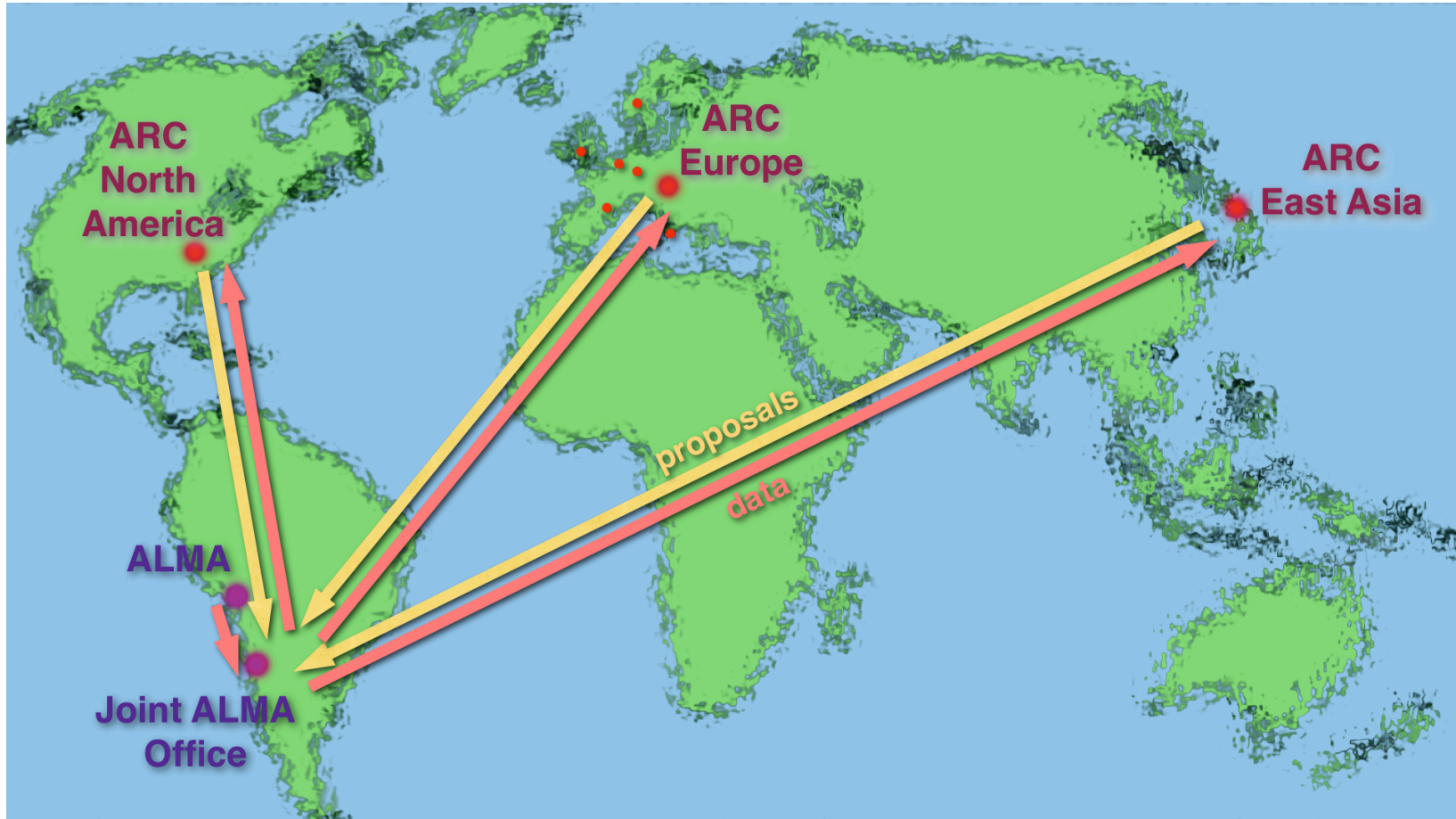


Getting ALMA data



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The ARCs and their relation to the JAO



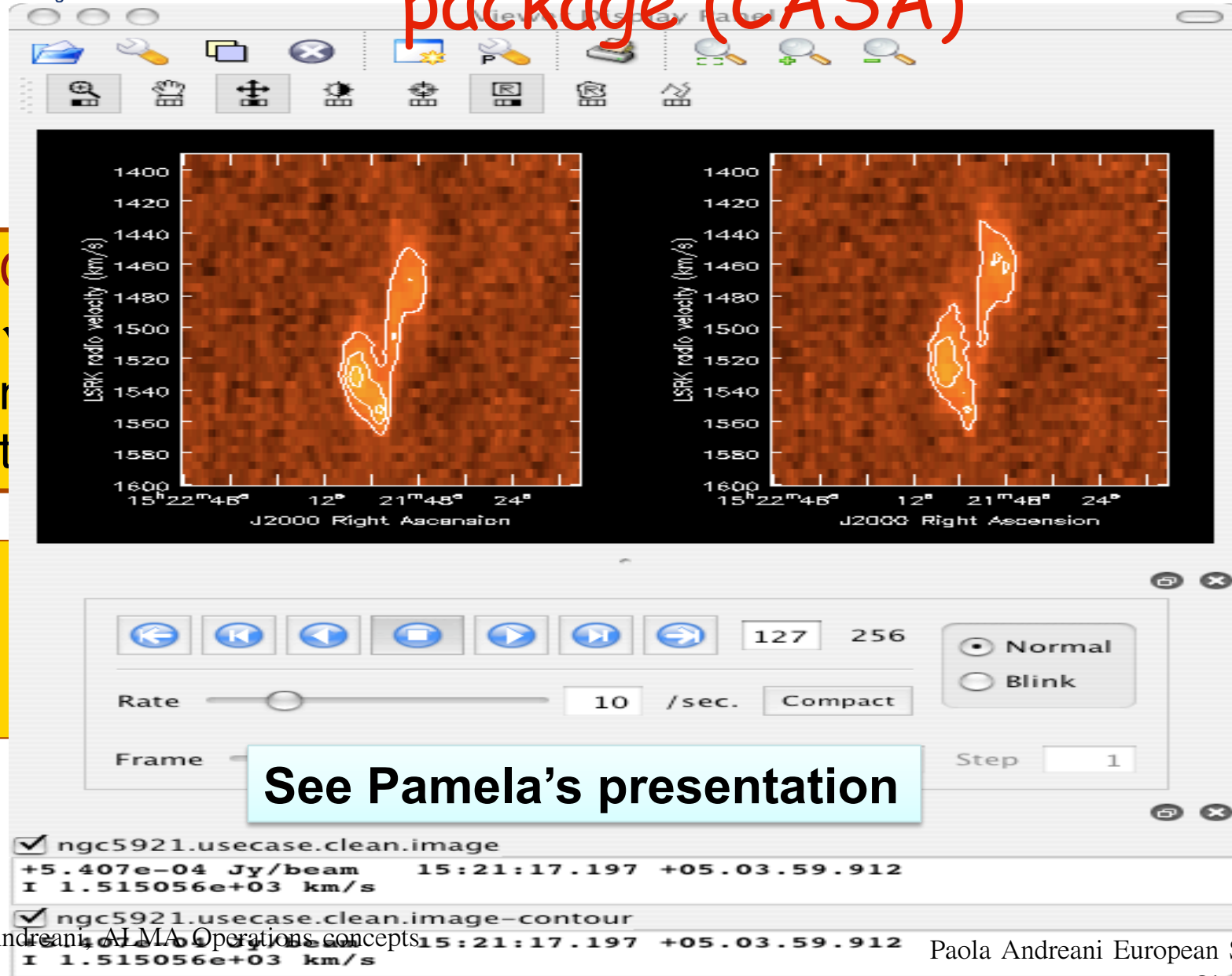
Data reduction



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The ALMA offline reduction package (CASA)



Simulating the data

ALMA simulator

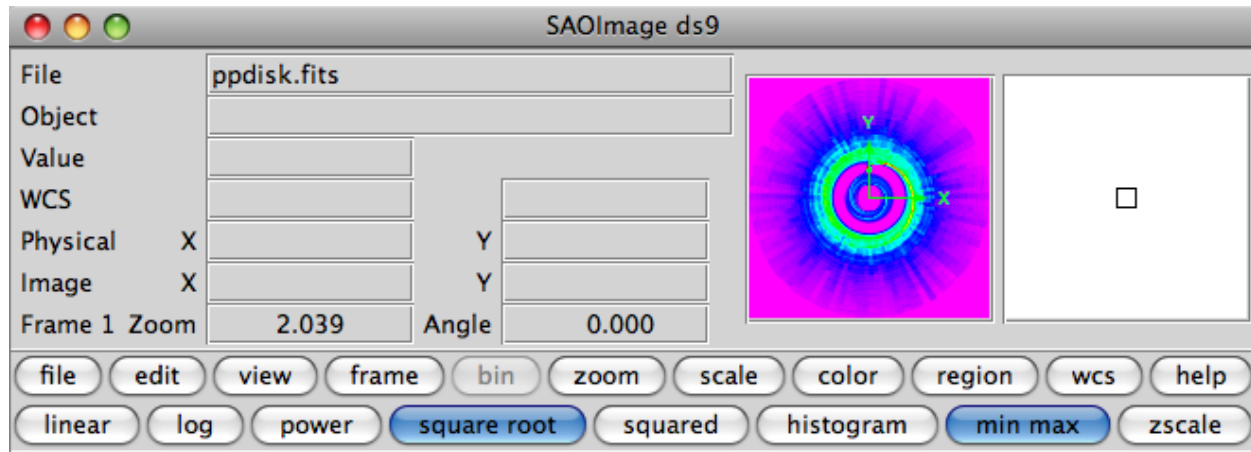
It is possible to simulate with the CASA package (see Pamela's talk) observations with ALMA.

The ALMA simulator is a task (in CASA), which produces

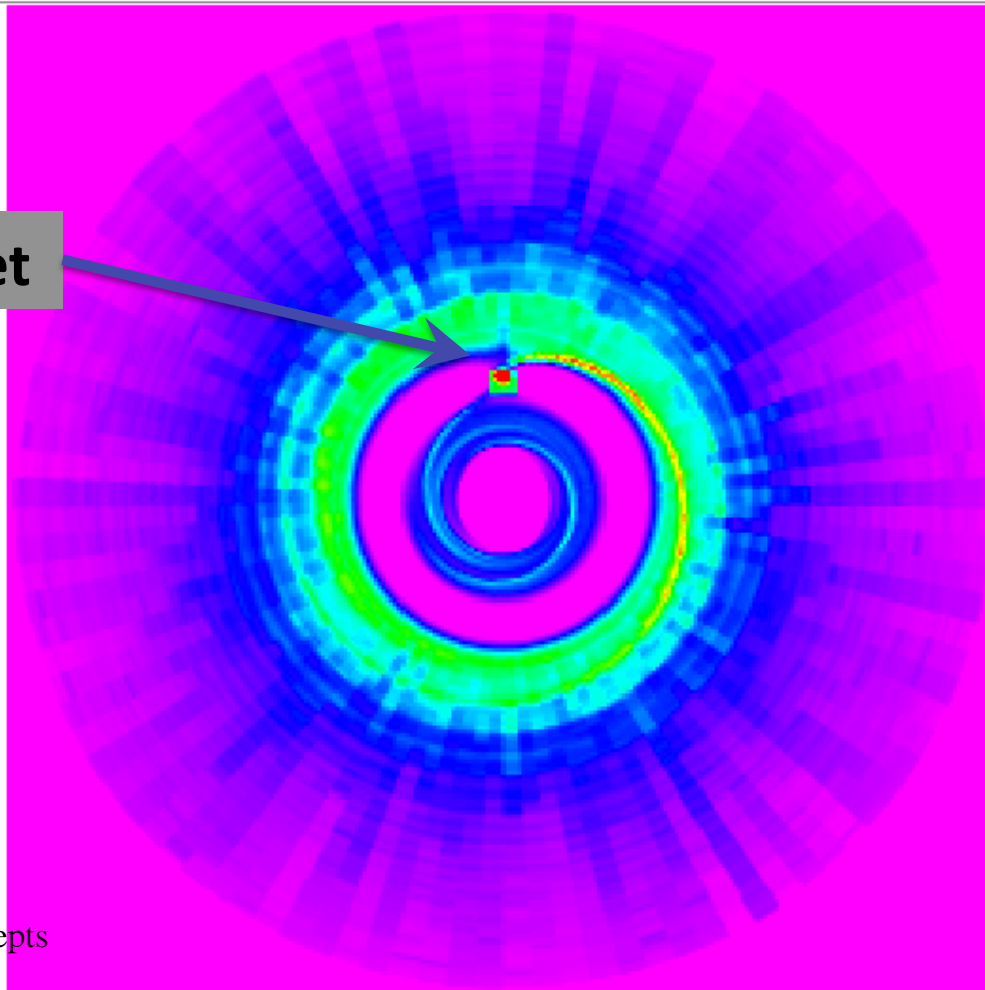
- synthetic visibilities
- a synthesized deconvolved image
- some analysis tools (image fidelity etc.)

The simulator models:

- thermal noise
- atmospheric phase delay (using a mock phase screen)
- cross-polarization leakage, gain drift



protoplanet



```

IPy testing
IPy testing  Default
CASA <51>: inp
-----> inp()
# almasimmos :: ALMA mosaic simulation task (pro
modelimage      = 'ppdisk.im'      # input
incell           = '8.63888953e-7deg' # input
inbright         = 0.067459        # input
                                     # (Jy/sq arcsec)
complist        - ''              # componentlist table to observe
antennalist      = 'almaconfig.out22' # antenna position file
project          = 'sim'           # root for output files
refdate          = '2012/05/21/22:05:00' # center time/date of observation
totaltime        = '7200s'        # total time of observation
integration      = '10s'          # integration (sampling) time
startfreq        = '668.0GHz'     # frequency of first channel
chanwidth        = '8.0GHz'       # channel width
nchan            = 1              # number of channels
direction        = ['J2000 19h00m00 -40d00m00'] # mosaic center, or list of
                                     # pointings
pointingspacing  = '0.1arcsec'     # spacing in between beams in mosaic
relmargin        = 1.0            # space btw. pointings and edge,
                                     # relative to pointingspacing
cell             = '0.004arcsec'   # output cell/pixel size
imsize           = [192, 192]     # output image size in pixels (x,y)
niter            = 200            # Maximum number of iterations
threshold        = '0.0mJy'       # Flux level (+units) to stop cleaning
psfmode          = 'clark'         # method of PSF calculation to use
                                     # during minor cycles
weighting        = 'natural'       # Weighting to apply to visibilities
uvtaper          = False          # Apply additional uv tapering of
                                     # visibilities.
stokes           = 'I'            # Stokes params to image
noise_thermal    = False          # Add thermal noise
fidelity         = True           # Calculate fidelity images
display          = True           # Plot simulation result images,figures
async           = False          # If true the taskname must be started
                                     # using almasimmos(...)

CASA <52>: █

```

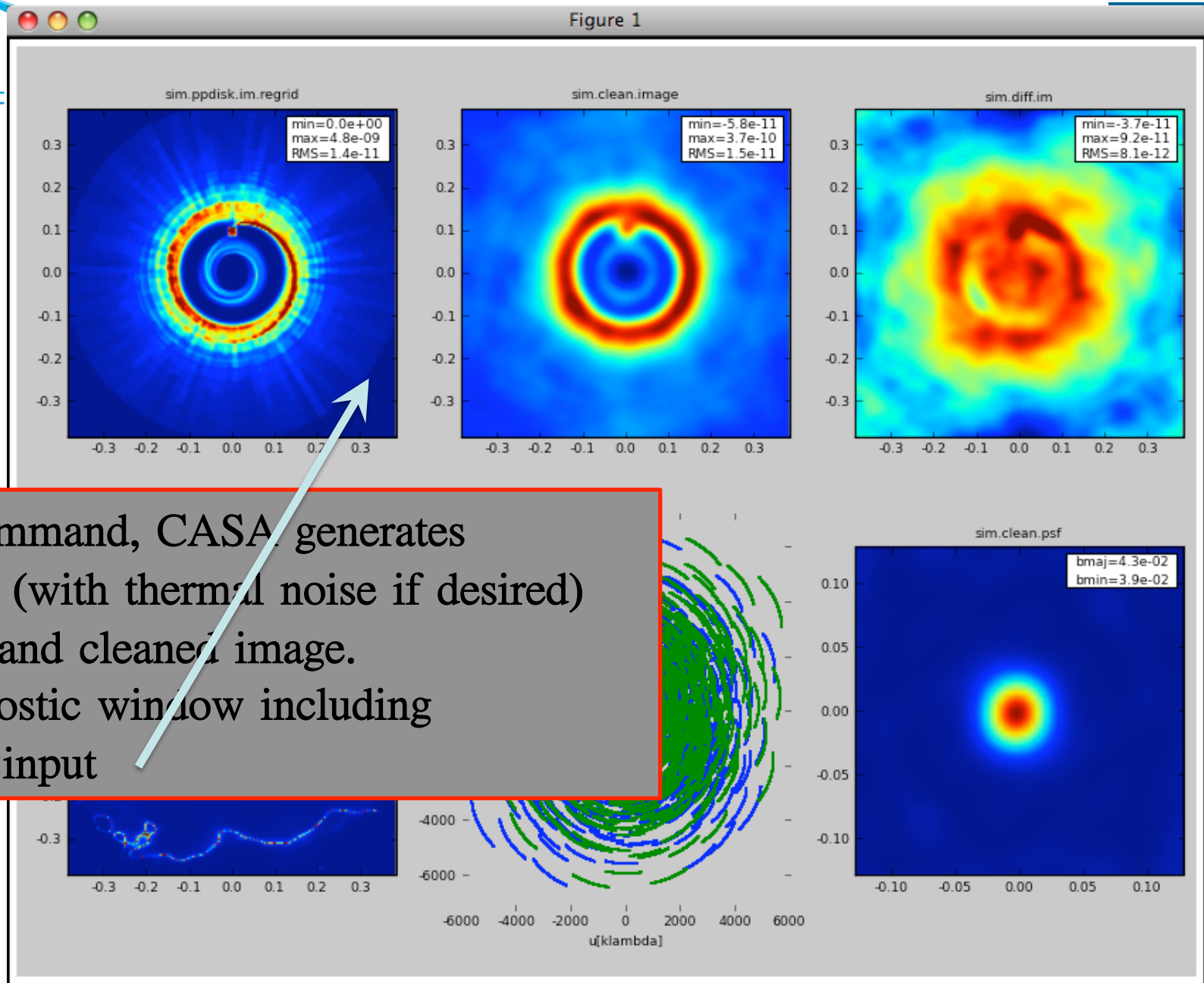
Your desired observation (array, time) is easily entered at the CASA user interface



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niter          = 200            # Maximum
threshold      = '0.0mJy'      # Flux level
psfmode        = 'clark'       # method
weighting      = 'natural'     # weighting
uvtaper        = False         # Apply taper
stokes         = 'I'           # Stokes
noise_thermal  = False        # Add thermal noise
fidelity       = True          # Calculate fidelity
display        = True          # Plot simulation result images, figures
async          = False         # If true the taskname must be started
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```

Your desired observation (array, time) is easily entered at the CASA user interface

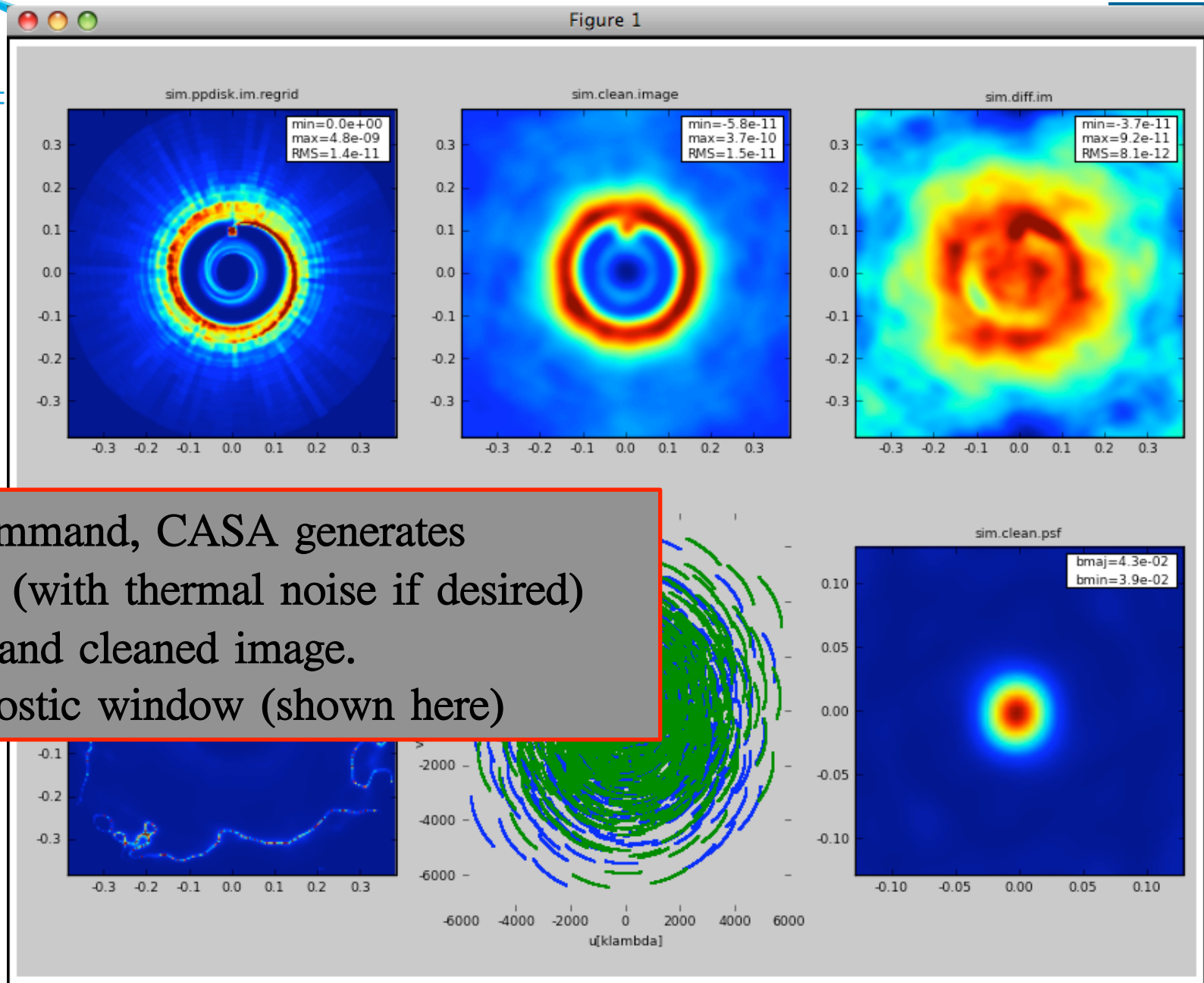
As well as details of the input model, if you wish e.g. to change size or frequency, and details of how to image the data.



In one command, CASA generates

- uv data (with thermal noise if desired)
- a dirty and cleaned image.
- a diagnostic window including
 - your input

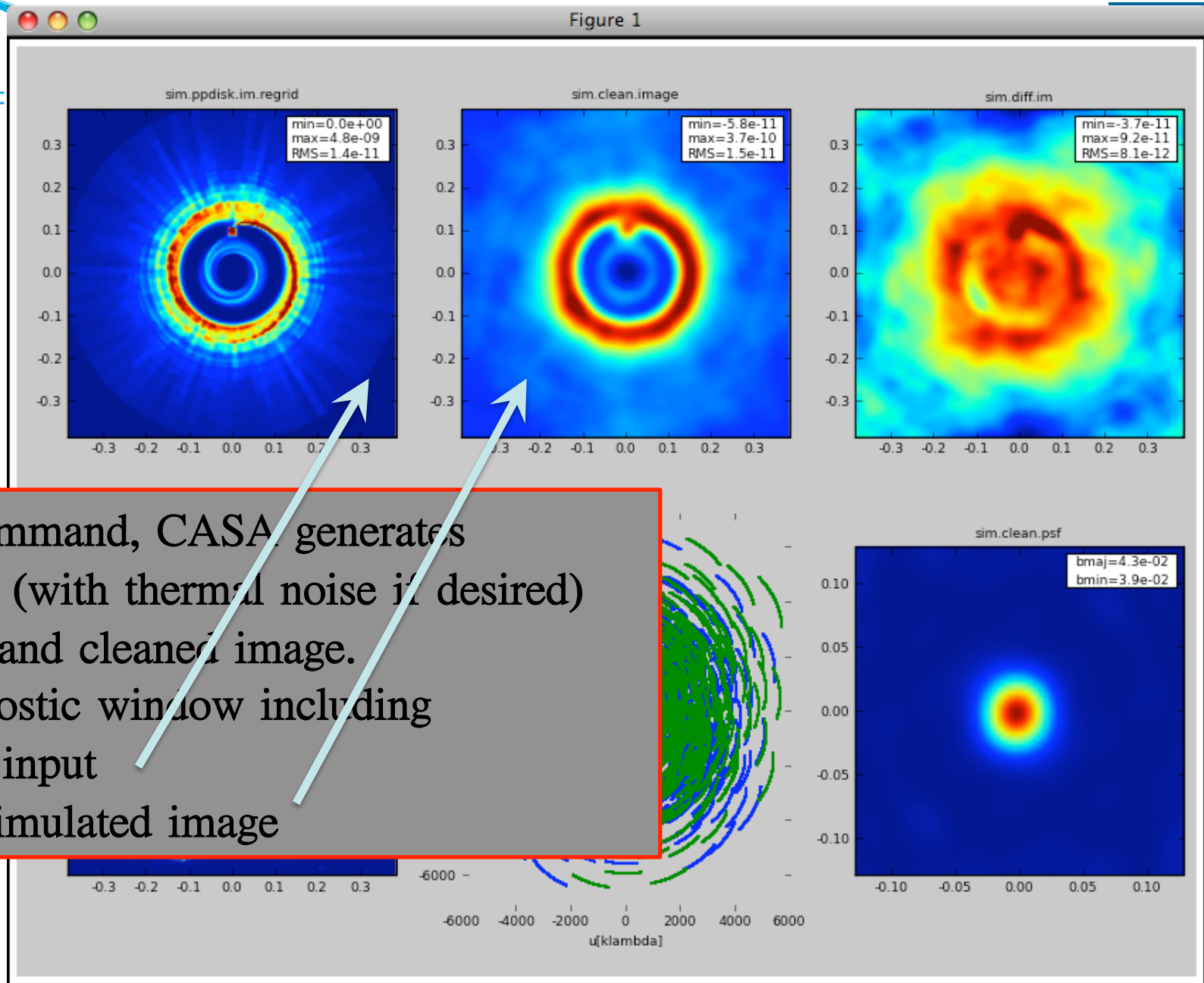




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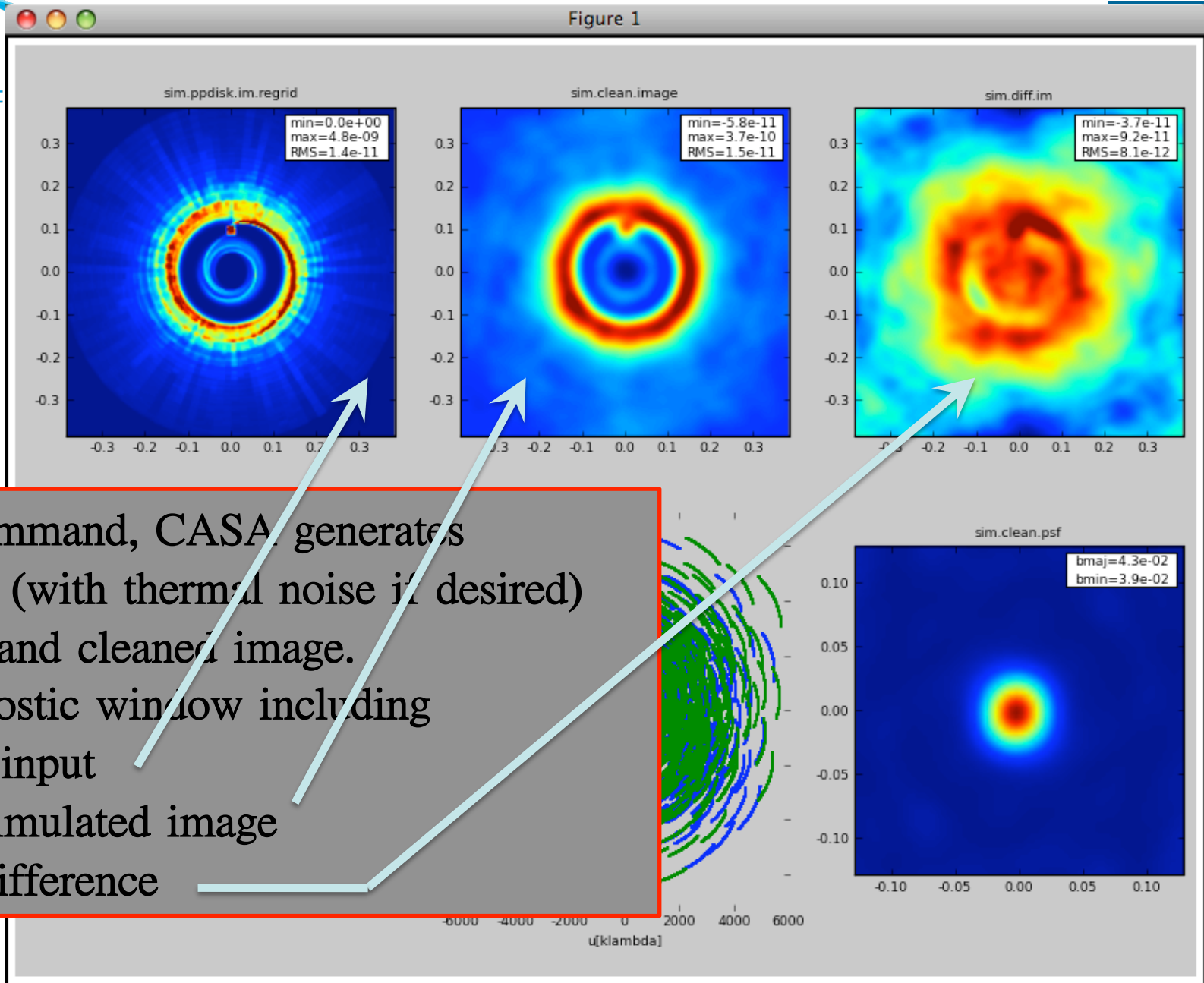
- uv data (with thermal noise if desired)
- a dirty and cleaned image.
- a diagnostic window (shown here)





In one command, CASA generates

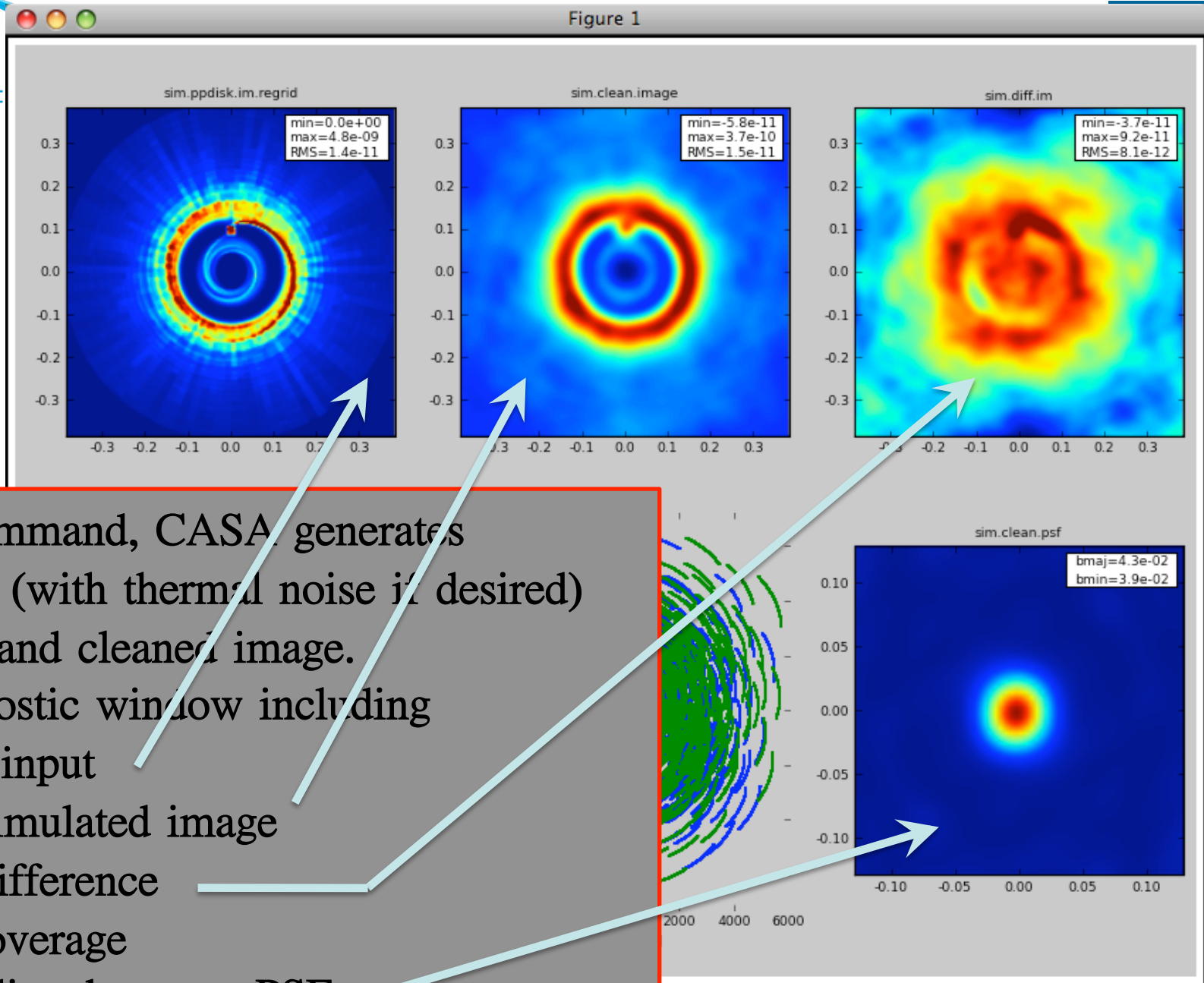
- uv data (with thermal noise if desired)
- a dirty and cleaned image.
- a diagnostic window including
 - your input
 - the simulated image



In one command, CASA generates

- uv data (with thermal noise if desired)
- a dirty and cleaned image.
- a diagnostic window including
 - your input
 - the simulated image
 - the difference





- In one command, CASA generates
- uv data (with thermal noise if desired)
 - a dirty and cleaned image.
 - a diagnostic window including
 - your input
 - the simulated image
 - the difference
 - uv coverage
 - and dirty beam or PSF



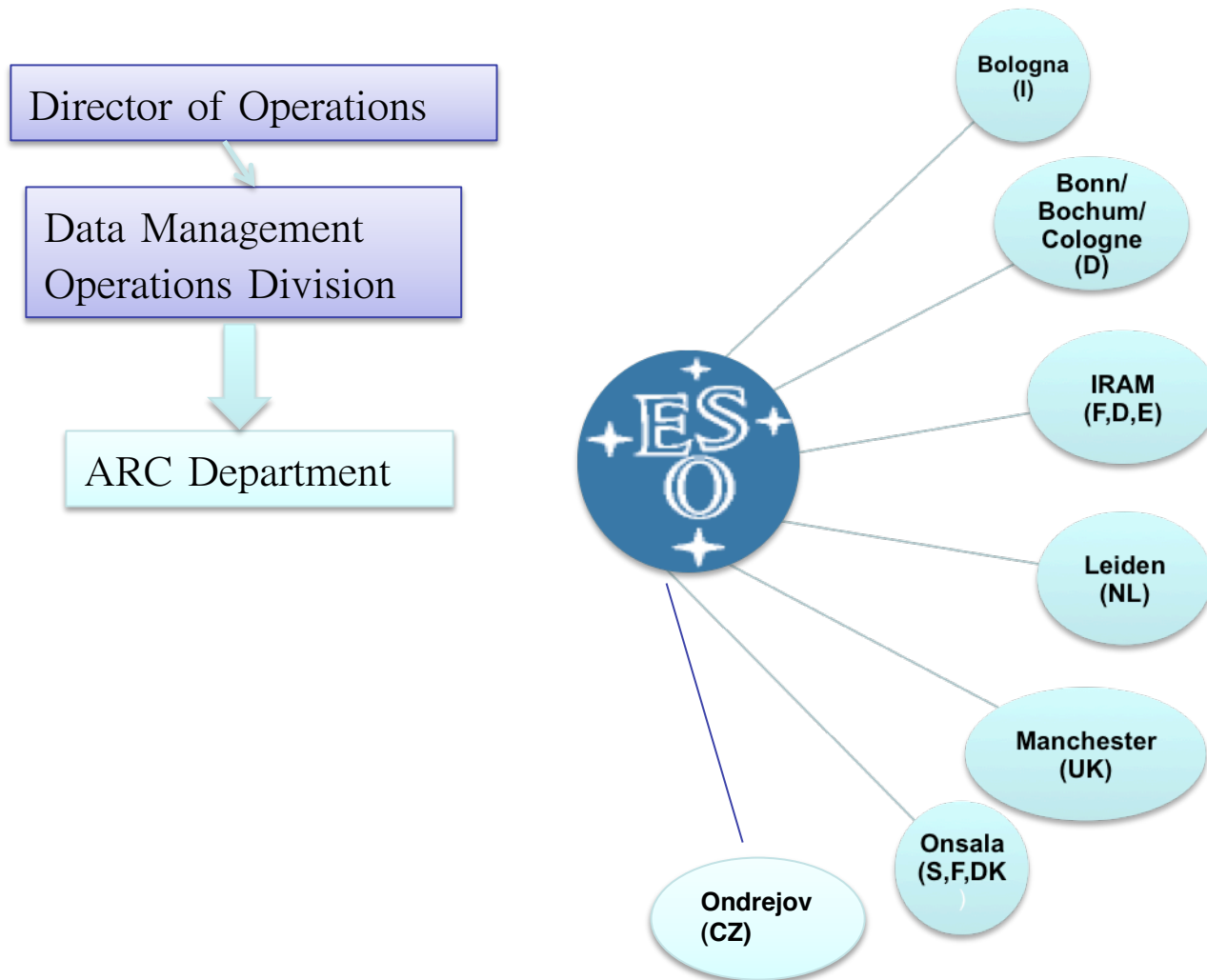
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The ALMA Regional Centres



The European ARC

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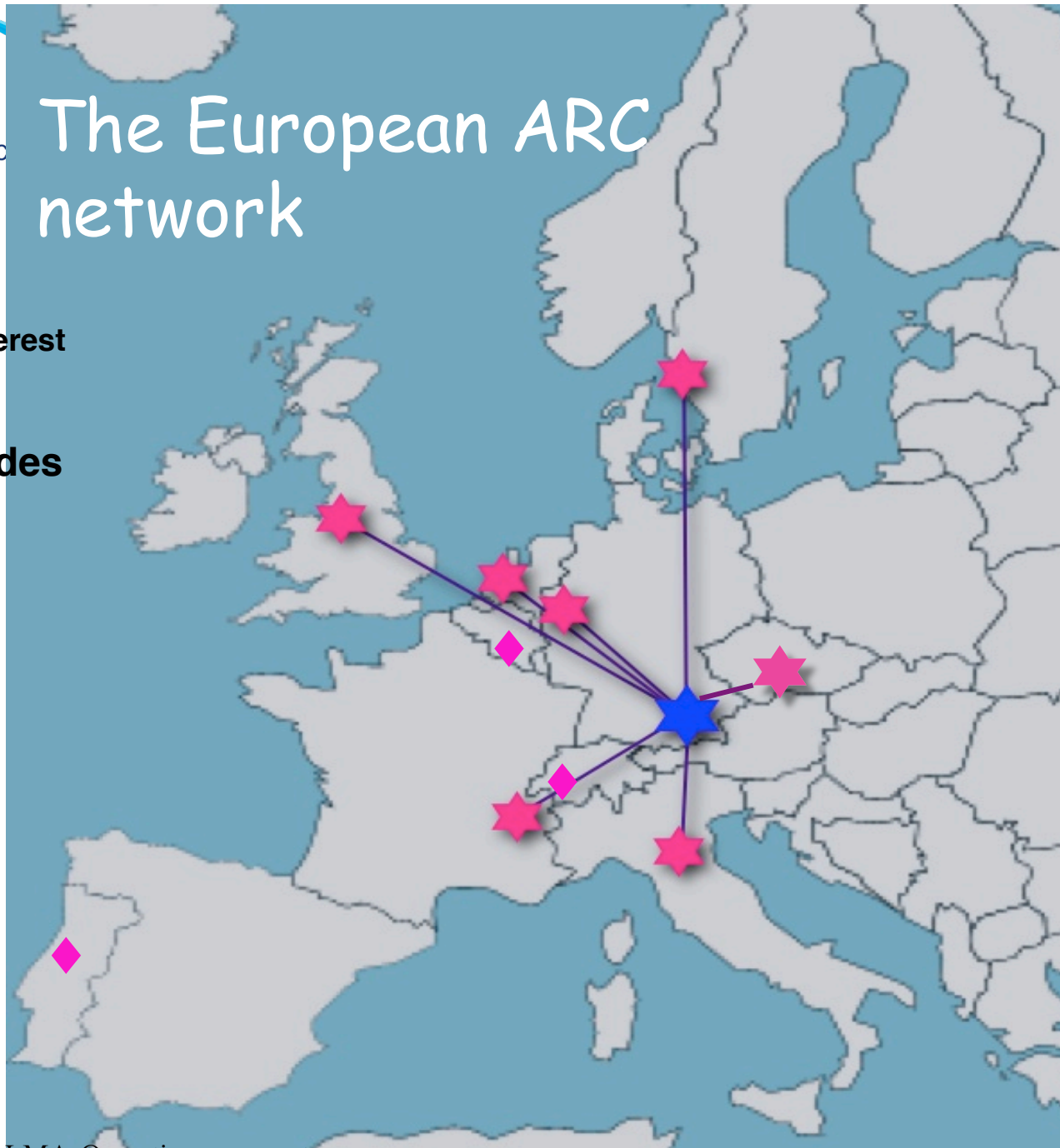


The European ARC network

The European ARC network

◆: express interest

☆: ARC nodes





EUROPEAN ARC

The European ARC



Core functions

- Scientific support:
 - Proposal & observation preparation
 - user support
- Archive Operations:
 - host a copy, data delivery
- Astronomer on duty at OSF
- Science community activity
- User support:
 - f2f help

ESO: ARC Department

ARC nodes

Non-core functions

- Data reduction
 - Advanced pipeline
 - Extended archive support
 - Support for special projects
 - Science community activity:
 - training, schools, workshops

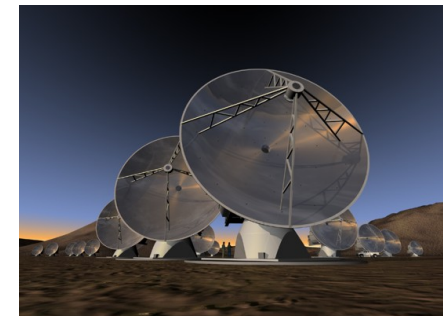
ARC nodes

ESO ARC + nodes

ALMA simulators

Current Timeline

- **Start of CSV (Commissioning and Science Verification): Jan 2010 (3 antennas at the AOS)**
- **ESDP (Early Science Decision Point): End 2010 (call for proposals)**
 - Mirror Archives in place
 - ALMA User Portal activated
 - ALMA Helpdesk activated
- **Deadline for proposals (Early 2011)**
 - PRC review procedure initiated
- **Deadline for PRC final ranking (Mid 2011)**
 - Preparation of SBs
- **Start Early Science: Autumn 2011**
 - Take and deliver data
- **Inauguration: September 2012**
 - More than 50 fully equipped antennas
- **Baseline ALMA Construction Complete 2013**



- Start Science Operations before the ALMA construction finishes
- Conditions for Early Science Operations:
 - 16 antennas with at least 4 receiver bands
 - Single field interferometry and pointed mosaics
 - Baselines out to 1 km
 - Basic set of spectral line modes
 - Single dish mapping (zero baseline observations) of extended objects in continuum and spectral line mode
 - Calibration better or comparable with existing mm-arrays
- Early Science Operations
 - One year scheduling period
 - Time shared with commissioning. At least 33% of available time will be used for observations

Questions ?