

A User's Guide to ALMA Scheduling Blocks (Cycle 4)



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Contributors

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OT Version

The following is a guide for interpreting ALMA Scheduling Blocks (SBs), using the ALMA Observing Tool (OT). You will need to download and install the latest version of the OT from the ALMA Science Portal at www.almascience.org. To check that you're using a version of the OT set up for working with SBs, click the "Help" menu, then click "About" and select the "Version" tab. You should see *PhaseII* in the User version (see *Figure 1*). If not, then download a more recent version from the Science Portal. (The user version is also shown on the startup screen.)

This particular document has been updated for use with the ALMA OT user version Cycle4PhaseII(u1).

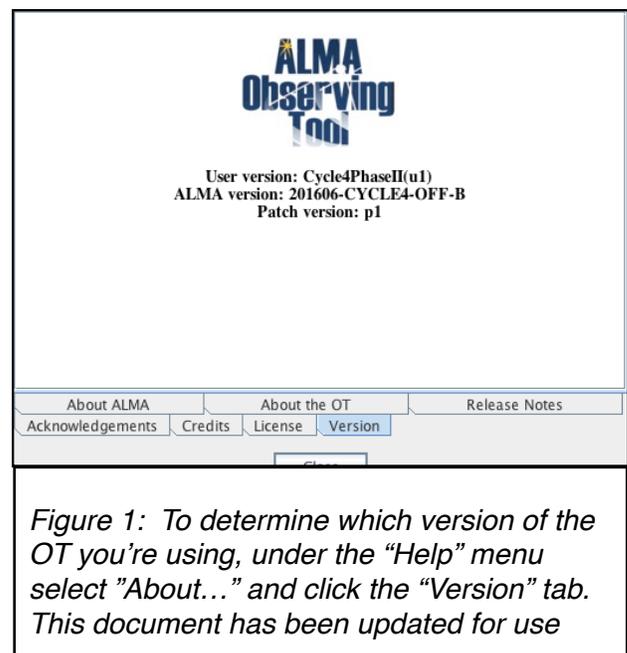


Figure 1: To determine which version of the OT you're using, under the "Help" menu select "About..." and click the "Version" tab. This document has been updated for use

A Users' Guide to ALMA Scheduling Blocks (SBs)

Introduction

When preparing your ALMA proposal (a process often referred to as *Phase 1*) with the ALMA *Observing Tool* (OT), you created one or more *Science Goals* (SGs; *Figure 2*) in which you specified the science targets and properties, observing frequencies and correlator settings, required sensitivities, and other observing constraints. These can be viewed by clicking the “Proposal” tab (*Figure 2*). After your project is approved, your proposal enters *Phase 2* (visible under the “Program” tab (*Figure 3*), in which your SGs are used to generate *Scheduling Blocks* (SBs) which contain all the instructions needed by the telescope control software to carry out your science and calibration observations. Before generating your SBs, you will need to follow the procedures listed in the *Phase 2 Quickstart Guide* available on the Science Portal at <http://almascience.org/documents-and-tools/cycle4/phaseii-userguide>. Once your SBs have been generated, this document will help you to interpret your SBs and how they relate to your SGs and to the observations they will be used to carry out. Remember, however, that you can always contact your Contact Scientist (CS) through the Helpdesk if you have any questions or concerns. (Note that VLBI and solar SBs are not included in this document.)

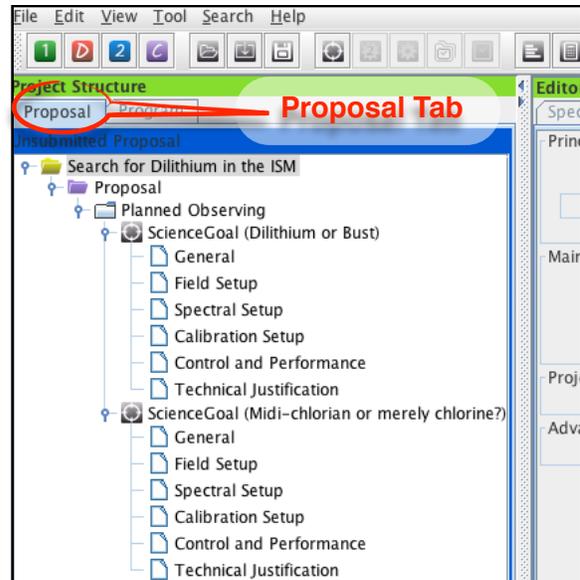


Figure 2: The “Proposal” tab shows the Science Goals (SGs) exactly as they were generated by you when you prepared your proposal. The contents under this tab cannot be edited or changed.

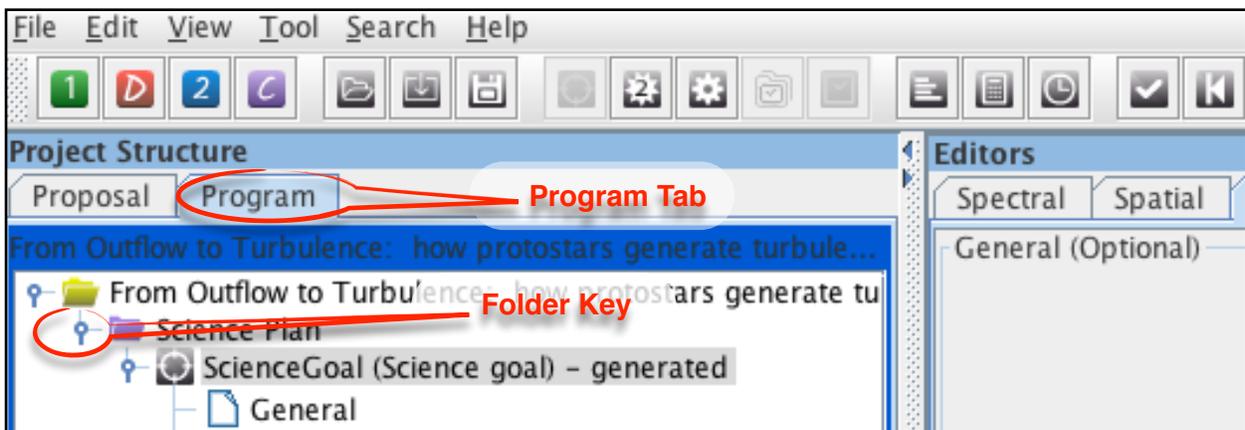


Figure 3: The “Program” tab (circled) contains the files generated at Phase 2, including the SBs. Clicking the folder key symbol exposes or hides the contents of the file. Right-clicking the key symbol and selecting “Expand all” allows you to see all the files under that key.

Structure of SBs

Once you've generated your SBs, you'll see a set of nested folders, similar to when you created your SGs. To expand the folders, just click on the key symbols (circle with a line segment; *Figure 3*) or expand them all using *cntrl-z* or *right-click* → *expand all*. The top level folder is the *Project*, the second level is the *Science Plan*, and the third level of this hierarchy contains the *Science Goals*. So far this is the same structure as you saw when generating your proposal. At Phase 2, a hierarchy of files called Observing Unit Sets (OUSs; see *Figure 4*) is created from each SG, inside of which you'll find your SBs. (For a full description of the OUS hierarchy, see the *Technical Handbook*, Chapter 8.)

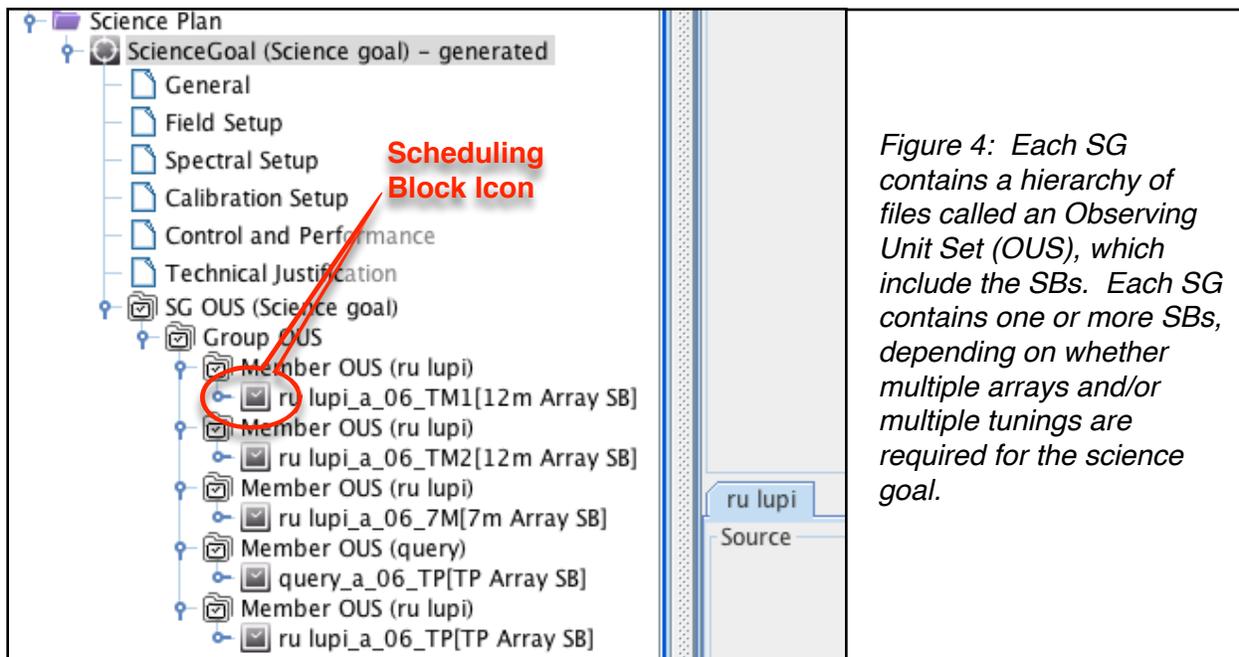


Figure 4: Each SG contains a hierarchy of files called an Observing Unit Set (OUS), which include the SBs. Each SG contains one or more SBs, depending on whether multiple arrays and/or multiple tunings are required for the science goal.

Depending on the angular resolution, largest angular structure (LAS), number of tunings, and sky distribution of science sources specified in the SG, at Phase 2 one or more SBs will be generated for each SG, each in its own Member OUS. The SB can be identified by a square clock icon (*Figure 4*).

SB Naming Convention

Each SB in your project has a unique name, with the structure SRCName_a_XX_AR, where 'SRCName' is the first (up to) 8 characters of the representative science target, 'XX' is the receiver band used (e.g. 03 for Band 3), 'AR' distinguishes the array ('TM1' or 'TM2' for the 12m-Array, '7M' for the 7m-Array, and 'TP' for the TP-Array), and 'a' has the value 'a', 'b', 'c', etc., to give the SB a unique name.

An example of an SB name might be 'ru_lupi_b_03_TM1', where 'ru_lupi' comes from the first (up to) 8 letters of the representative science source in the SB, 'b' means that there is another SB in the project with a similar name (i.e. ru_lupi_a_03_TM1), '03' means the SB uses the Band 3 receivers, and '_TM1' means that this is a 12m Array observation. (If you had chosen

an angular resolution and LAS combination that required two 12m Array configurations, the SB for the second, more compact configuration would have been labeled ‘_TM2’; see *Figure 4.*)

Each SB is made up of three sections: *Groups*, *Targets*, and *Resources* (*Figure 5*).

Groups

All observing targets that are to be executed are included in a *Group* within the SB. Each SB can include multiple *Groups*. The first, *Group 1*, generally contains the initial calibration observations (*e.g.* amplitude, bandpass, sideband ratio, *etc.*), and the targets within this Group are intended to be done once per execution of the SB. (Note, however, that for spectral scans, *Group 1* is empty.) The second (or subsequent) Group contains the science targets plus relevant calibrators (*e.g.* phase, atmosphere, pointing, *etc.*) which are repeated until the science integration time is completed. If you click on a group, then the targets associated with that group are highlighted in yellow.

Targets

Targets define all the information needed for an observation, using *Resources* (see below). There is one *target* for each science source or calibrator. Clicking on a target causes all of the resources associated with that target to be highlighted in yellow (*Figure 5*). All of the resource parameters for the target are also shown at the same time in the *Editor* window (*Figure 6*).

One of the science *targets* is labeled with an ‘[R]’. This target is used as a representative target for the SB when the Scheduler is looking for available SBs to observe.

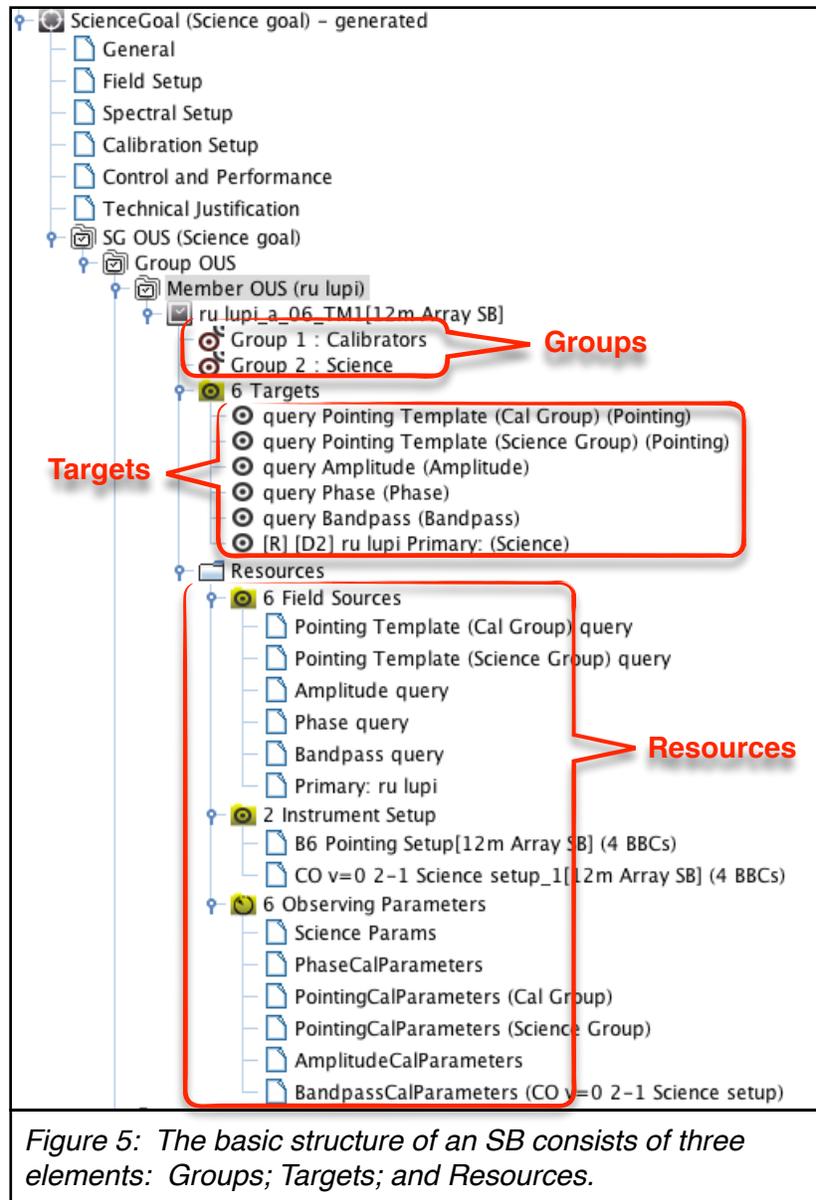


Figure 5: The basic structure of an SB consists of three elements: Groups; Targets; and Resources.

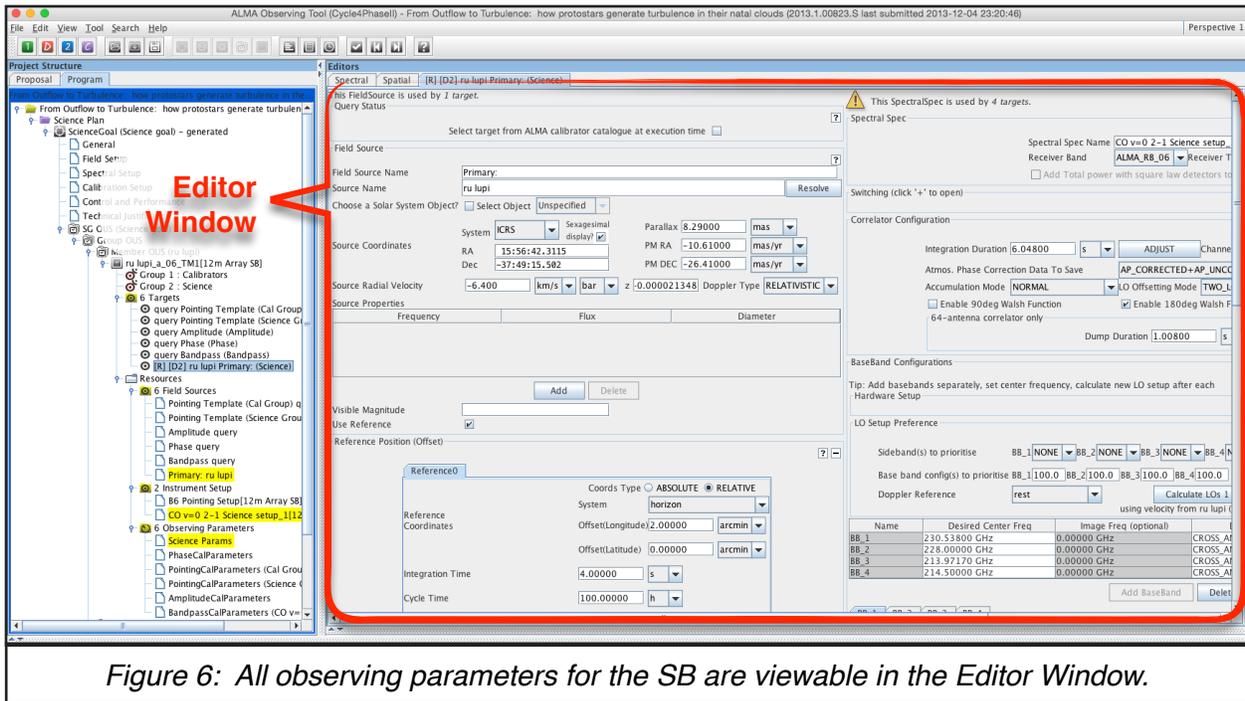


Figure 6: All observing parameters for the SB are viewable in the Editor Window.

Resources

Resources define the parameters used for a particular type of observation. A *resource* may be used by several *targets*. Clicking on the *resource* will highlight the *targets* making use of it in yellow. It also shows the parameters for that *resource* in the Editor window.

There are three types of resources (*Figure 5*):

Field Sources

Field Sources define the position (plus proper motion and parallax), offsets and radial velocity of each source, including calibration sources. If multiple science sources were defined in the SG, each will have its own *field source*. Calibration *field sources* are usually left as a *query*, to be defined at the time of the observation. Calibration sources, because they tend to be variable, are monitored periodically by the observatory. If there is no suitable calibrator in the catalogue, a “cone search” may be carried out prior to observing your SBs.

Instrument Setup

The *instrument setup* defines how the receiver is tuned and the correlator is set up. Usually there are two setups: one for pointing, and one for the science observations, but in certain circumstances (e.g. multiple tunings for a spectral scan, multiple sources with different redshifts, very narrow total bandwidth) there may be several science setups.

Observing Parameters

Observing parameters define the sub-scan duration (basic integration time) and the total integration time per execution of the SB for each *target*, as well as other parameters.

Examining Your SBs

The most common items that you might want to check in your SBs are the science source positions and radial velocities, the instrument setups, the integration time, and the array configuration in which the SB might be observed. We look at each item in turn.

Science Source Positions and Radial Velocity

Each science source has its own *Field Source* resource (Figure 7), where the source position and radial velocity are defined. These values are copied directly from your SGs when the SBs are generated, so in most cases will be unchanged. To see them, clicking on the *Field Source* (e.g. in Figure 7, the *Field Source* for RU Lupi) reveals the parameters in the Editor window to the right. Where a mosaic or offsets have been specified, you may need to scroll down the Editor window to see them (Figure 8). Total Power (_TP) science observations require a reference position, which your Contact Scientist will request you to provide. That can be checked by scrolling down the Editor window.

On the top left corner of the Editor window (Figure 9), if you click on the Spatial tab you can get a graphical view of the source position, offsets and mosaic positions. This view works the same way as when you generated your SGs in Phase 1.

The screenshot shows the software interface with the Project Structure on the left and the Editors window on the right. The Editors window is set to the 'Spatial' tab for the 'Primary: RU Lupi' field source. A red circle highlights the 'Field Source' section, which includes fields for Source Name (RU Lupi), Source Coordinates (RA: 15:56:42.3115, Dec: -37:49:15.502), Source Radial Velocity (-6.400 km/s), and Source Properties (Frequency, Flux, Diameter). Other visible fields include Parallax (8.29000 mas), PM RA (-10.61000 mas/yr), and PM DEC (-26.41000 mas/yr).

Figure 7: The Field Source resource, showing the position, radial velocity and velocity frame, proper motion, and other properties.

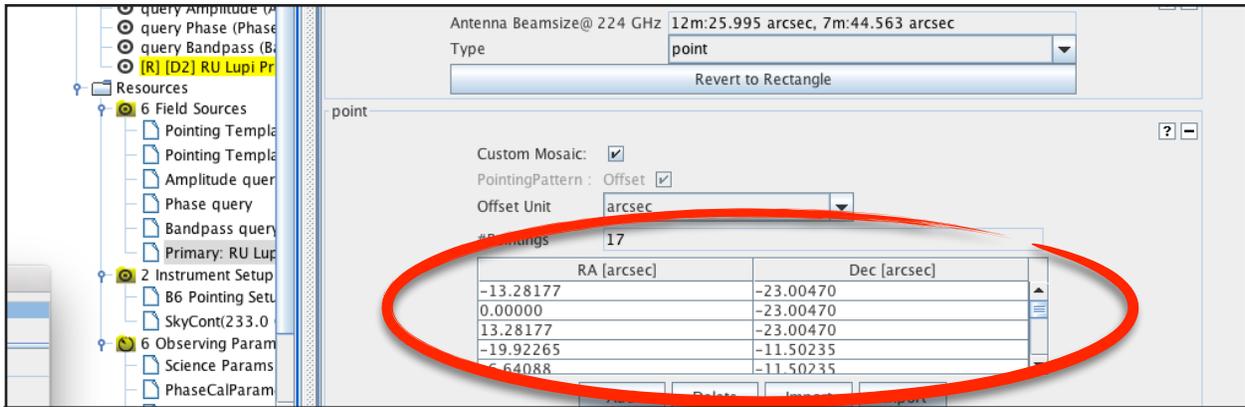


Figure 8: Offset positions (e.g. for a mosaic) are found by scrolling to the bottom of the Editor window in the Field Source resource.

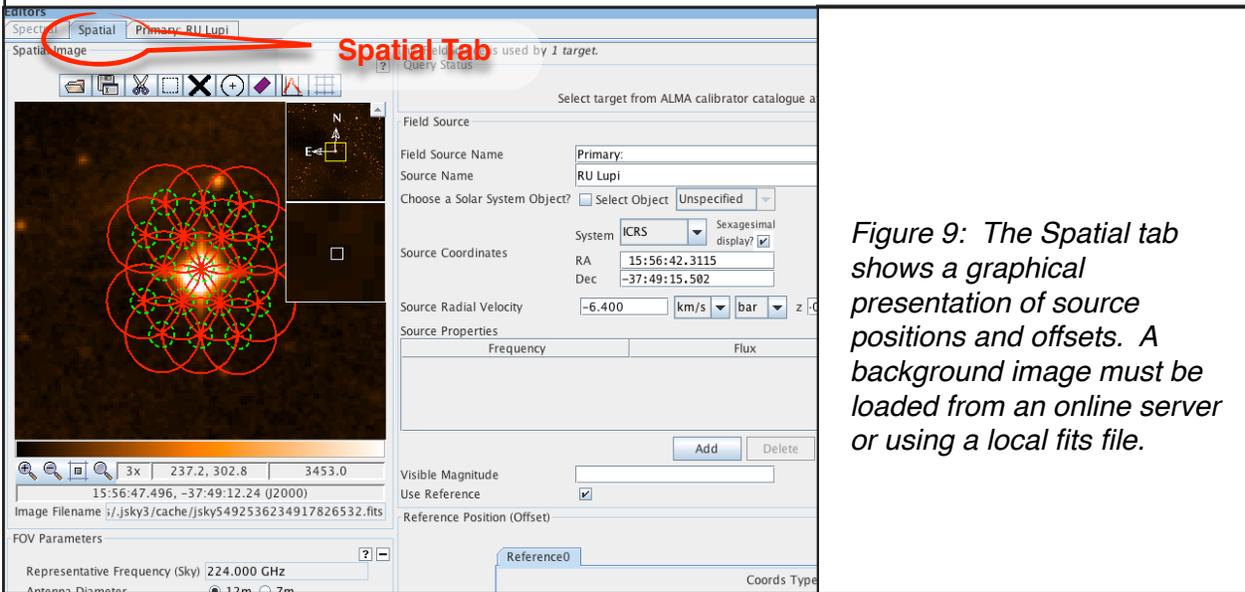


Figure 9: The Spatial tab shows a graphical presentation of source positions and offsets. A background image must be loaded from an online server or using a local fits file.

Instrument Setup

Because of the power and flexibility of the ALMA correlator, the *Instrument Setup* resources are much more complex than the other resources, and interpreting them can be daunting. However, in most cases only a few numbers are relevant and can be checked quickly.

Click on the *Science Instrument Setup* resource (see Figure 5). The targets using this setup are highlighted in yellow. Scrolling down the *Editor* window, near the bottom you'll see (up to) four tabs, one for each baseband (BB_1, BB_2, etc.; Figure 10). Click on each baseband tab in turn. At the bottom of each baseband window is another set of 1-4 tabs, one for each spectral window (SW-1, SW-2, etc.; Figure 10). Click on each of these tabs in turn to check the center frequency of the spectral window (rest and sky), the bandwidth, averaging factor, and spectral resolution (after smoothing and averaging).

If you have multiple SBs within an SG (Figure 3) due to multiple array configurations, then all of the 12-m and 7-m Array SBs (_TM1, _TM2, _7m) and the science TP-Array SB (e.g. ru_lupi_a_03_TP), should all have identical science instrument setups. The TP-Array calibration SB (query_XXX_TP) may have a different instrument setup from the others.

Baseband Tabs

BB_1 BB_2 BB_3 BB_4

Baseband Name: BB_1

Desired Center Freq: 230.06552 GHz

Desired Image Freq (Optional): 0.00000 GHz

Actual Center Freq: 230.06552 GHz

Actual Center Freq (Sky): 230.07044 GHz

Products: CROSS_AND_AUTO

Spectral Window Tabs

Offset (MHz)	LSB(Rest)	use LSB	USB(Rest)	use USB	Bandwidth	Chs	Channel Spacing	Polarization	Output Data Rate
3472.4731445...	---	<input type="checkbox"/>	230.538 GHz	<input checked="" type="checkbox"/>	125.0 MHz	2048	61.03515625...	XX,YY	3.881 MB/s
2527.5268554...	---	<input type="checkbox"/>	229.593 GHz	<input checked="" type="checkbox"/>	125.0 MHz	2048	61.03515625...	XX,YY	3.881 MB/s

Center Frequency

SW-1 SW-2

Spectral Window Name: SW-1

Center Offset Frequency: 3472.473144531250 MHz

Uncorrected Center Offset Frequency: 3472.473144631266 MHz

Equivalent Omega IF2: 2.527526855468750 GHz

Center Freq(Rest) LSB/USB: 230.537987558352650 GHz

Center Freq(Sky) LSB/USB: 230.542909159381250 GHz

Nominal BW / # Channels: 125.000 MHz / 2048

Effective BW / # Channels: 117.1875 MHz / 1920

Channel spacing: 61.035156250000 kHz

Polarization Products: XX,YY

CorrConfigMode/FilterMode: 45 TFB

Window Smoothing Function: HANNING

Averaging Factor: 1

Resolution: 122.070312500000 kHz

Bandwidth

Polarization

Spectral Averaging Factor

Resolution after smoothing/averaging

Figure 10: Click on the Science Instrument Setup and scroll to the bottom of the Editor window in order to check your correlator setup. Each baseband (BB) has its own tab, and each spectral window (SW), if more than one within the baseband, has its own tab. Click on each in turn to check the setup for each spectral window in each baseband.

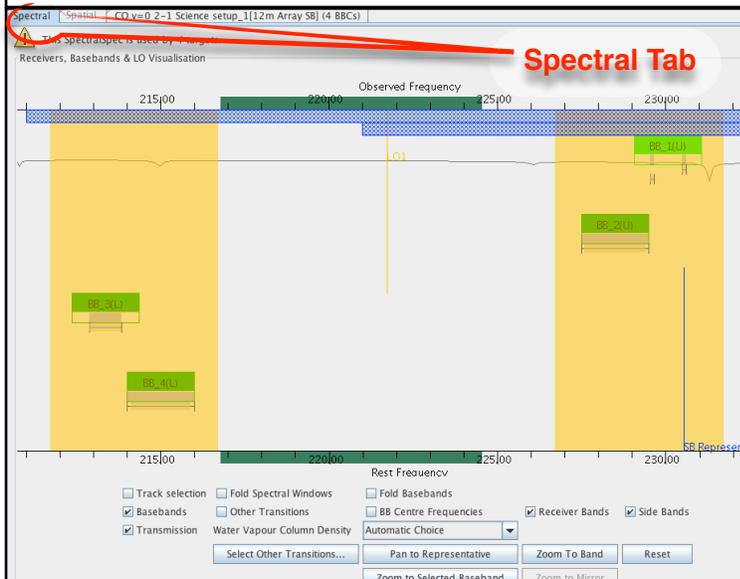


Figure 11: A graphical view of the correlator setup using the Spectral tab, showing the ranges for each baseband as well as the bandwidth and range of each spectral window.

Note that the *Center Frequency* of the spectral window may be slightly different from the desired center frequency, by as much as 20 MHz. This is because the OT calculates the full correlator tuning solution while generating the SBs, and the solution may differ slightly from the desired value. This may be a significant fraction of your spectral window width when using narrow windows.

On the top left corner of the Editor window, if you click on the Spectral tab you can get a graphical view of the correlator setup (Figure 11). This view is similar to the Spectral view when you generated your SGs in Phase 1, except that now both the baseband location and width as well as all spectral window widths are shown graphically.

Integration Time

Click on the *Science Observing Parameter* resource (Figure 5). The target(s) using this setup will be highlighted in yellow. In the Editor window (Figure 12) you can check the *Integration Time on Source*, which is the total integration time (per execution of the SB) for each target using this resource (Figure 12). (For targets with multiple offsets, e.g. mosaics, the integration time per point will be the *integration time on source* divided by the number of offsets.) The *integration time on source* is limited so that the SB will be completed in approximately 2 hours or less including all calibration observations, so it will often be shorter than the total integration time required. In this case, the SB may need to be executed multiple times. Click on the SB icon (grey clock) and scroll down to *Execution Count* (Figure 13). The overall

The screenshot shows the 'Science Params' tab in the Editor window. The 'Integration Time on Source' field is set to 25.2 min and is circled in red. A red arrow points from the text 'Total Integration Time On-Source per SB Execution' to this field. Other fields include 'Representative Bandwidth' (0.12207 MHz), 'Representative Frequency' (230.54292 GHz), and 'Sub Scan Duration' (30.24000 s).

Figure 12: The Science Observing Parameter resource shows, among other things, the total integration time on source per execution of the SB.

The screenshot shows the 'Standard Interferometry' mode configuration. The 'Execution Count' field is set to 2 and is circled in red. A red arrow points from the text 'Number of SB Executions' to this field. The 'Max. Time' is set to 2.00000 h. The 'Obs. Procedure' is 'StandardInterferometry.py'.

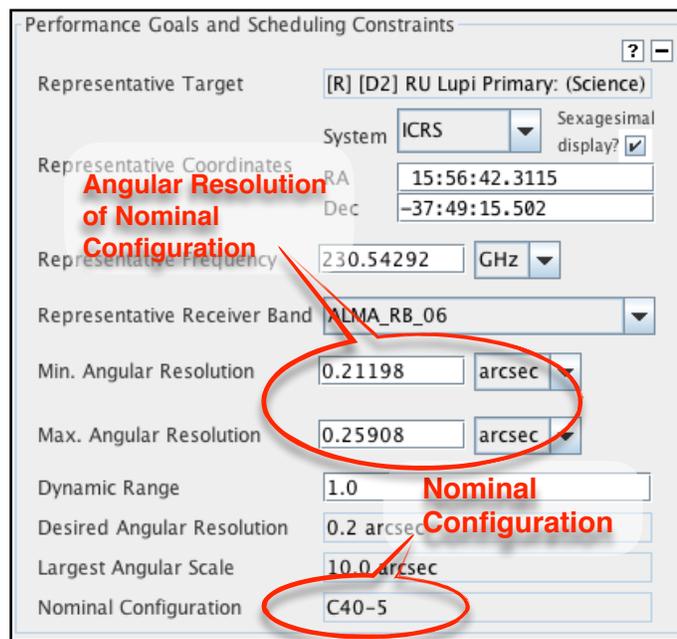
Figure 13: Click on the SB name (yellow clock icon) and scroll down the Editor window to find the Execution Count. The total time on source will be the Integration Time on Source (Figure 12) multiplied by the Execution Count.

total integration time on source is then the *execution count* multiplied by the *integration time on source*.

Note that if more than one array configuration is required for your SG (e.g. a second, more compact 12m-Array configuration, and/or the ACA, etc.), then the integration time for the more compact configuration(s) will be governed by the required integration time for the most extended configuration (i.e. the SB with the ‘_TM1’ at the end of its name). For Cycle 4, the integration time for the compact 12m-Array configurations (‘_TM2’) will have 30% of the total integration time on source as the more extended configuration SB (‘_TM1’); the 7m-Array and TP-Array SBs have a more complicated formula for determining the total integration time.

Array Configuration

Currently the ALMA observing software uses the values of angular resolution (AR) and Largest Angular Scale (LAS) stored in the *Control and Performance* section of the SG to determine which array configurations are suitable for observing your SBs. Click on the SB icon (square grey clock) and scroll down to the bottom of the editor window (*Figure 14*) to see the nominal configuration which the OT determines gives the closest value to your requested AR. The OT also displays a “minimum” and “maximum” angular resolution, which is effectively the angular resolution of the nominal configuration (+/- 10%). If multiple 12m Array configurations are required to achieve the LAS you’ve requested, then the _TM2 SB will show the nominal configuration and angular resolution (+/- 10%) of the more compact 12m Array configuration. To confirm which array configurations are likely to be used for your SBs, consult with your Contact Scientist through the ALMA Helpdesk.



Performance Goals and Scheduling Constraints

Representative Target [R] [D2] RU Lupi Primary: (Science)

System ICRS Sexagesimal display?

Representative Coordinates RA 15:56:42.3115
Dec -37:49:15.502

Angular Resolution of Nominal Configuration

Representative Frequency 230.54292 GHz

Representative Receiver Band ALMA_RB_06

Min. Angular Resolution 0.21198 arcsec

Max. Angular Resolution 0.25908 arcsec

Dynamic Range 1.0

Desired Angular Resolution 0.2 arcsec

Largest Angular Scale 10.0 arcsec

Nominal Configuration C40-5

Nominal Configuration

Figure 14: Click on the SB icon and scroll to the bottom of the editor window to see the Nominal Configuration, i.e. the configuration which provides the closest angular resolution to the PI-requested AR, in which the SB is most likely to be observed. The Min./Max. Angular Resolution displayed is the range of resolutions achievable with the nominal array (depending on the chosen weighting during data reduction).

Other Considerations

For other observing constraints, such as time constraints, observing cadences, TP-array setups, etc., consult with your Contact Scientist through the ALMA Helpdesk.

Appendix A - Acronyms used

ACA - Compact array, including 7m Array and TP Array

ALMA - Atacama Large Millimeter/Submillimeter Array

AR - Angular Resolution

BB - baseband

CS - Contact Scientist

FDM - correlator spectral mode

JAO - Joint ALMA Observatory

LAS - Largest Angular Structure

OT - ALMA Observing Tool

PT - Project Tracker

SG - Science Goal

SB - Scheduling Block

spw - spectral window

TDM - correlator continuum mode

TP Array - total power array, part of ACA



The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of the European Organization for Astronomical Research in the Southern Hemisphere (ESO), the U.S. National Science Foundation (NSF) and the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Republic of Chile. ALMA is funded by ESO on behalf of its Member States, by NSF in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and by NINS in cooperation with the Academia Sinica (AS) in Taiwan and the Korea Astronomy and Space Science Institute (KASI).

ALMA construction and operations are led by ESO on behalf of its Member States; by the National Radio Astronomy Observatory (NRAO), managed by Associated Universities, Inc. (AUI), on behalf of North America; and by the National Astronomical Observatory of Japan (NAOJ) on behalf of East Asia. The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.

