ALMA Observing Tool Reference Manual

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NRAO

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Contributors

The ALMA OT Team, and the many Testers.

Contributors' Logos

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 OT Reference Manual 1.6, Ver. 1.0

Contents

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Chapter 1

Introduction

1.1   Purpose

The Observing Tool (OT) provides a comprehensive set of interfaces and tools with which observing proposals and observations with the Atacama Large Millimeter/submillimeter Array (ALMA) can be prepared. The full description of the OT and how to prepare the observations using the OT can be found in the ALMA OT User Manual (available from the Science Portal and from within the OT).

In the OT the user will be confronted with various fields and interfaces with a large number of menus, input fields and buttons that need to be completed and/or used for defining a proposal or observing project. A major fraction are mentioned and briefly described in the various chapters of the OT User Manual. However, for readability reasons more comprehensive descriptions of the OT fields and menus were not included.

This ALMA OT Reference Manual contains these descriptions and definitions. The information is basically arranged in the same order as they are presented in the User Manual and as the user will most likely use the OT. The many entry fields of the OT are arranged into multiple panels and the information presented here also groups the information in this way.

Chapter 2 provides descriptions of the main OT menu and its tool bar at the top of the OT as well as some additional information about the OT graphical interface. Chapter 3 describes the buttons of the Tools and Simulators e.g. the ALMA Sensitivity Calculator (ASC) and the calibration selection tools. In Chapter 5, information is provided for the parameters required for completing Phase-1 and Phase-2 Science Goals whilst Chapter 6 provides references for constructing Phase-2 Scheduling Blocks (SBs). Note that defining SBs requires a solid knowledge of interferometry in general and ALMA in particular. Descriptions for the Visual Spatial and the Visual Spectral Editors are provided in Chapters 7.1 and 7.2.

To provide a good overview of "what is where", all descriptions are accompanied by one or more figures that show the corresponding menu, interface or toolbar.

1.2   Release Information

The current version of the manual is intended to be consistent with the OT Release for Cycle 1 (released 31 May 2012).

1.3   Credits and Acknowledgements

The ALMA OT is a software product of the ALMA Observation Preparation Software Team and is developed on the basis of the ALMA Science Software Requirements (SSR) and the ALMA High Level Analysis (HLA) documents, produced by the respective groups. The OT software group acknowledges the valuable inputs of

these groups during the development phases of the OT. Also, the OT software groups thank the OT external community testing group for their testing efforts of the various versions of the OT.

Chapter 2

Overview of the Observing Tool

The OT main GUI contains three major components: the Menu bar at the top, followed by the toolbar containing the most frequently used Menu functions. To the left is the Project Structure tree and, to the right of this, are the various editors (Forms, Spectral and Spatial) that allow a user to complete the information required for each node within the Project tree. The appearance of the main OT GUI is similar to that shown in Figure 2.1.
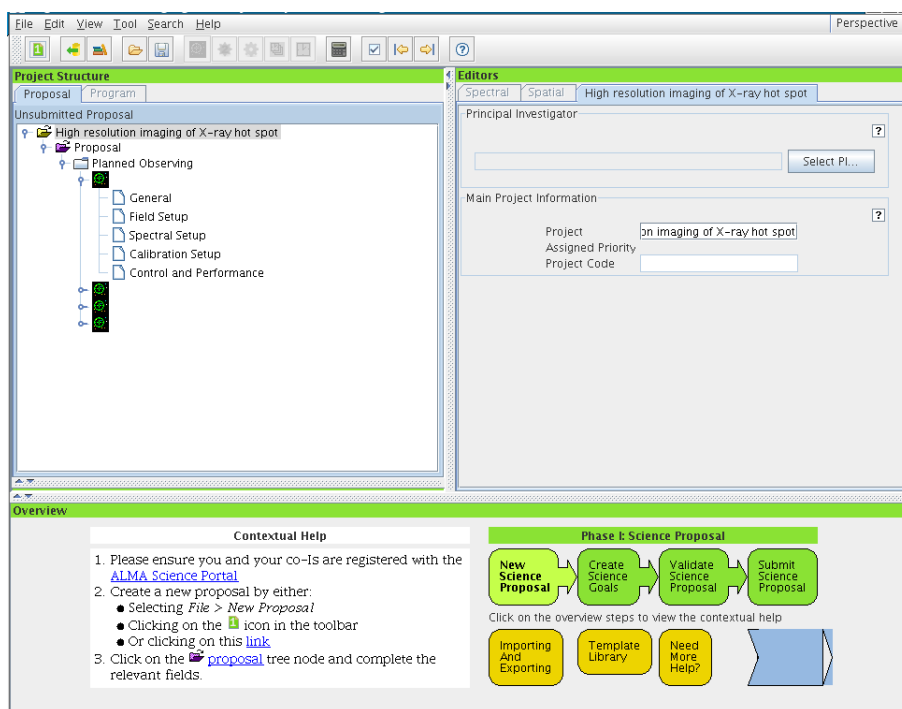

Figure 2.1: The Observing Tool main GUI.

2.1   Menu Bar

The **Menu** bar gives access to a variety of OT functions and tools.

Figure 2.2: The Menu Bar of the Observing Tool main GUI.

2.1.1 File

File contains submenus for managing projects (project validation, open, save, retrieve, import and export, etc), for handling standard or project libraries, and to exit the OT.

- **New Proposal**: Create a new Phase-1 proposal using Science Goals.

- **New Program**: Create a new Phase-2 program using Science Goals or Scheduling Blocks.

- **Open Project**: Open a project from the local disk or use the Project Finder. A project can also be retrieved from the ALMA Archive.

- **Save**: Save a project to the local disk by overwriting the previous version.

- **Save As**: Save a project to the local disk, either by overwriting the previous version or as a new file.

- **Show ALMA Template Library**: Open the ALMA Template Library in a new Project tree window.

- **Use Project as Template**: Open a local ALMA project and show it in read-only mode.

- **Validate**: Validate the project currently loaded in the OT.

- **Submit Project**: Submit the project to the ALMA Archive for validation and proposal review if appropriate.

- **Submit As New**: Submit the current project to the ALMA archive as a new project. The project will obtain a new project code and so should be used with caution. It is only available to users with special privileges.

- **Preferences**: Set various appearance and behavioural preferences.

- **Quit**: Exit the OT.

2.1.2 Edit

Edit is used for project editing functions (cut, paste, delete, rename) and for adding/deleting project components like Science Goals of SB parameters. Note that the availability of the function depends on which component of a project has been selected.

- **Cut**: Cut a selected Science Goal or Scheduling Block item.

- **Copy**: Copy a selected Science Goal or Scheduling Block item. The copied item will turn pink.

- **Paste**: Paste a copied item.

- **Rename**: Rename various Project tree items.

- **New Phase 1 Science Goal**: Create a new Phase-1 Science Goal.

- **New Phase 2 Science Goal**: Create a new Phase-2 Science Goal.

- **Add Observatory Setup**: Add a special Observatory setup as part of the Science Plan. Observatory setups can be: Holography setup, Astro-Holography setup, Optical Pointing Science Goal, Radiometric Pointing Goal, Baseline Calibration Goal, Calibration Survey Goal.

- **Add ...**: Add a component to the Project Structure (OUS, SB, Target, etc.).

- **Attach/Detach ...**: Attach/detach a SB Field Source, Instrument Setup or Observing Parameter to/from a SB Target.

- **Delete**: Delete a selected Science Goal or Scheduling Block item.

- **Suspend**: Suspend the observation of this Scheduling Block.

- **Resume**: Allow further observation of the Scheduling Block.

- **Mark as Repaired**: Mark the Scheduling Block as repaired.

- **Terminate**: Terminate the observation of the Scheduling Block.

2.1.3   View

- **Feedback**: Enable or disable the Feedback panel.

- **Overview**: Enable or disable the Overview panel.

- **Show ALMA Template Library**: Show the ALMA Template Library in the Project Structure tree.

2.1.4   Tools

- **ALMA Calibration Selection Tool...**: Search for calibrators either using the ALMA online calibrator database, or using a more limited internal OT version. The tool is only available for Phase-2 programs.

- **ALMA LO Configuration Tool...**: Experiment with LO setups. Only recommended for expert users.

- **ALMA Calibration Time Estimate Tool...**: Experiment with calibration parameters. Only recommended for expert users.

- **Sensitivity Calculator...**: Start up the ALMA Sensitivity Calculator.

- **Generate SBs from the Selected Goal**: Create one or more SBs from the selected Phase-1 or Phase-2 Science Goal.

- **Generate Phase 1 SBs from all the Science Goals**: Create one or more SBs from all of the Phase-1 Science Goals.

- **Generate Phase 2 SBs from all the Science Goals**: Create one or more SBs from all of the Phase-2 Science Goals.

- **Show Printable Summary...**: Depending on which node of the Project tree is currently selected, this will give the option to view a summary of the proposal (displays the cover sheet, Technical Assessment flag sheet and summary of each Science Goal) or subsets of these.

- **Generate a a PDF for the Whole Proposal**: Create a PDF for the whole proposal.

- **Disable Edit Protect**: Disable the editing protection. Can be set via `Options` in the Menu.

2.1.5   Search

With **Search**, one can jump between the problems reported in the Feedback pane (see below).

2.1.6   Debug

Debug enables/disables debug facilities. This menu item is only displayed when `Debug` is activated via `Options` → `Advanced`. This option is for developers only.

2.1.7 Help

Help displays User and Reference Manuals as well as the Quickstart Guide and release information about the OT.

2.2 Tool Bar

The **Toolbar** contains buttons for executing frequently-used OT functions and tools. Below follows an overview of the Toolbar buttons. Note that the availability of the tools and functions depends on which phase of project one is working on and on permission settings.

Figure 2.3: The Toolbar of the Observing Tool main GUI.

- **New Proposal**: Create a new observing proposal.

- **New Observing Program**: Create a new observing program.

- **Open Project from ALMA Archive**: Open a project from the ALMA archive.

- **Show ALMA Template Library**: Open the ALMA Template Library.

- **Open Project from Disk**: Open a project from the local disk.

- **Save Project to Disk**: Save a project to the local Disk.

- **New Phase 1 Science Goal**: Create a new Science Goal. The Proposal or Planned Observing nodes must be selected.

- **New Phase 2 Science Goal**: Create a new Phase-2 Science Goal.

- **Generate SBs from the Selected Goal**: Create one or more SBs from a Phase-2 Science Goal.

- **Add an Observing Unit Set**: Add an ObsUnitSet to a Phase-2 program.

- **Add a Scheduling Block**: Add an SB to an ObsUnitSet.

- **Generate SBs for the Selected Goal**: Convert/map the Science Goal into SBs.

- **Sensitivity Calculator**: Start the Sensitivity Calculator.

- **ALMA Calibrator Selection Tool**: Start the Calibrator Selection GUI.

- **Validate**: Check whether a project .

- **Go to previous Problem**: Go to the previous reporting problem that was found by the validator and displayed in the Feedback pane.

- **Go to next Problem**: Go to the next reporting problem that was found by the validator and displayed in the Feedback pane.

- **Contextual Help**: Get help for the topic under the cursor when clicking.

2.3 Panes

2.3.1 Project Structure

The Project Structure pane shows the overall structure of the project. The visualisation of the project structure depends on which view is chosen. The tabs (which will be at the bottom or top) enable a user to select either Proposal (Phase 1) or Program (Phase 2).

2.3.1.1 Proposal

When selecting the Proposal tab the Phase-1 Project Tree becomes visible. The Phase-1 Proposal node contains all the administrative information needed for a proposal whist the the Science Goals are contained in the Planned Observing folder. They are organised as follows:

- **General**: The name and description of the Science Goal are provided here.

- **Field Setup**: This specifies target parameters, such as the name, coordinates, velocity and proper motion.

- **Spectral Setup**: Contains fields to specify the frequencies/transitions that should be observed.

- **Calibration Setup**: The details of the calibration are given here. User-defined is possible, but system-defined is recommended.

- **Control and Performance** This displays configuration information for the available arrays and accepts input for important control parameters such as the required sensitivity and largest source angular scale to be imaged.

2.3.1.2 Program

When selecting the Program tab, Phase-2 details can be added either in terms of Science Goals or by specifying Scheduling Block. The Phase-2 Science Goals forms are located under the Science Plan node and are identical to the forms for Phase 1 (see above). For each Science Goal, Science Plan contains an Observing Unit Set (ObsUnitSet) that allows the user to specify dependency rules for the SBs and hence the construction of a complex and detailed observing program. ObsUnitSets contain Scheduling Blocks (SBs) which are the key executable units of a project. SBs contain all necessary observing information to execute a "single" observation. A SB can be repeated several times to achieve the desired sensitivity or to reach the maximum allocated time. An SB consists of:

- **Targets**: Contains the sources to be observed, for science and calibration. Each of these has a Field Source, an Instrument Setup and a set of Observing Parameters. These are together called Resources.

- **Resources**:
  - **Field Sources**: Each field source defines the details of the source to be observed e.g. positions, velocities, observing pattern.
  - **Instrument Setup**: Specifies the various parameters for the frequency, baseband and correlator settings.
  - **Observing Parameters**: Contains for each target a set of representative observing and sensitivity parameters e.g. cycle and integration times, pointing offsets.

2.3.1.3 Template Library

The lower section of the Project Structure pane can be use to load the ALMA Template Library or to display a local ALMA project in read-only mode. Parts of the templates can be copied and used for an active project.
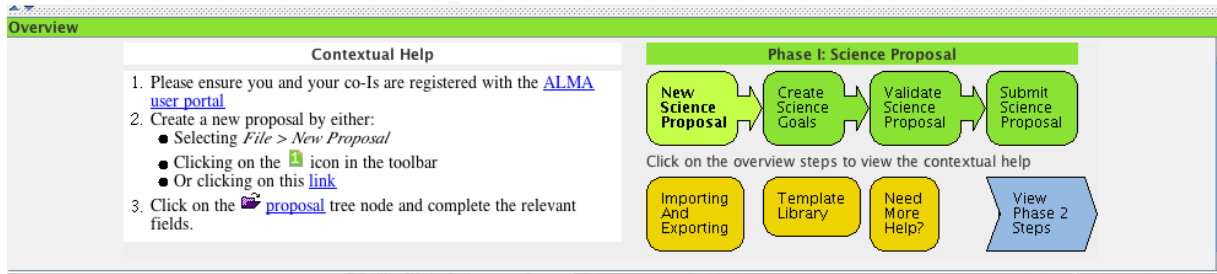
Figure 2.4: The Overview Panel.

2.3.2 Editors

The Editors pane contains the forms for entering spatial and frequency information of the observations in a project. The tabs can be used to choose between entering the data using the Visual Spatial/Spectral Editors or a plain form.

The Editors pane has three tabs:

- **Spectral**: Enables the Visual Spectral Editor to graphically visualise the frequency information for the receiver bands, sub-bands and correlator.

- **Spatial**: Enable the Visual Spatial Editor to display the science object obtained from one of the image servers available via the network.

- **Forms**: Displays the form corresponding to the mode that has been selected in the Project Tree. This can be part of a Science Goal or of a SB. While the forms for the Science Goals are relatively simple, more complex and elaborate forms need to be completed for creating a Scheduling Block. Note that the label of the tab depends on the node that has been selected in the Project Tree.

2.3.3 Feedback

The Feedback pane is for provides errors and/or warning when running the validator. There are three tabs: Validation, Validation History and Log.

- **Validation**: Shows a table of the errors and warning, and offers the possibility to jump directly to the erroneous item in the Project Tree. This is the main feedback window.

- **Validation History**: Enables previous validations to be viewed.

- **Log**: Miscellaneous application errors.

2.3.4 Overview

This panel displays an overview of the main tasks that an OT user needs to carry out in creating and submitting a Phase-1 proposal, followed by retrieving and completing the Phase-2 observing program. It aims to provide a quick, top-level guide, with brief contextual help. This is aimed at novice users; more experienced users can shrink the panel.

Chapter 3

Tools and Simulators

The OT is equipped with a number of tools: the Calibration Selection Tool, the Spectral Lines Selection Tool, the Sensitivity Calculator, the LO Configuration Tool and the Calibration Time Estimate Tool. The input for each of these tools is described below.

3.1 Calibrator Selection Tool

The tool allows the user to find calibrators within a defined distance from the target source. Note that the tool is only available for Phase-2 programs. The Calibrator Query Editor is available for Phase-1 proposals and Phase-2 programs, and looks very similar. The various filters are enabled with non-zero input.

- **RA**: The centre R.A. coordinate of the cone search.

- **Dec**: The centre Declination coordinate of the cone search.

- **Radius**: The search radius in degrees around the cone centre coordinates - 0 will use the whole sky.

- **Flux Min**: Minimum flux for the search.

- **Flux Max**: Maximum frequency for the search.

- **Frequency Min**: Minimum frequency for the search.

- **Frequency Max**: Maximum frequency for the search.

- **Max Results**: Maximum number of source to return [1-100].

- **Submit Query**: Query the ALMA Calibrator Database for possible calibrator given the constraints. Select either the ALMA Online Calibrator catalogue or the OT's internal (and less extensive) version.

- **Non-Sidereal Calibrators**: Display non-sidereal sources from the Calibrator Source Catalogue.

- **Select As ...**: Use the selected calibrator for one or more calibration types (amplitude, phase, pointing, polarization, focus, or bandpass). The button will display a window to make the selection for calibration purpose and the spectral specification.
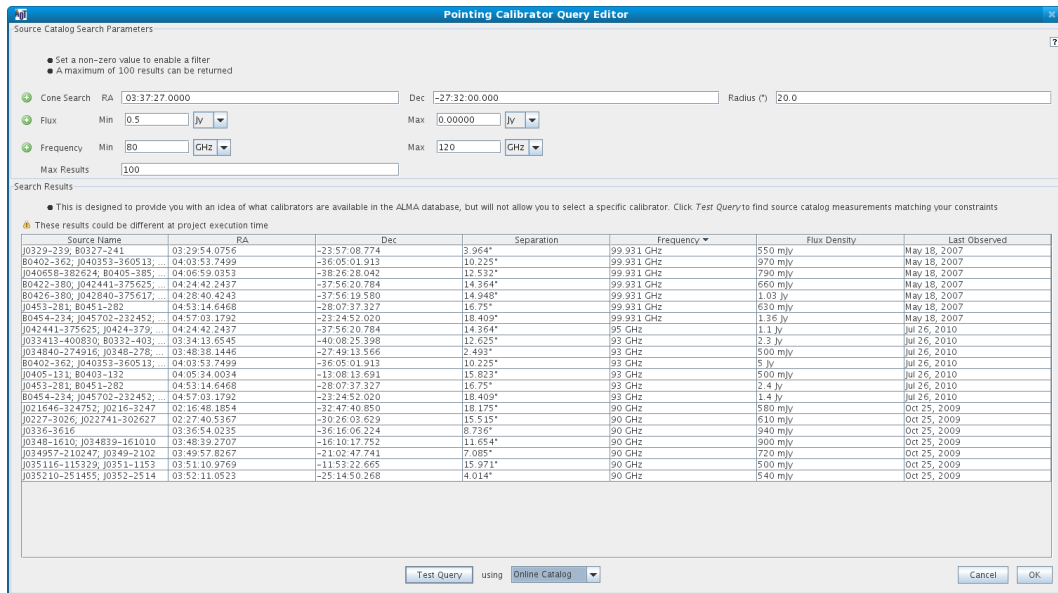
- **Close**: Close the tool.

Figure 3.1: The Calibration Selection Tool.

3.2 Spectral Lines Selection Tool

The ALMA spectral line catalogue contains the rest frequencies of millions of spectral line transitions. These transitions can be inspected and selected via this tool. The tool can be launched with the button `Select Lines to Observe` when defining the Spectral Setup of a Science Goal, or via the button `Line Catalogue` when defining the Instrument Setup of an SB.
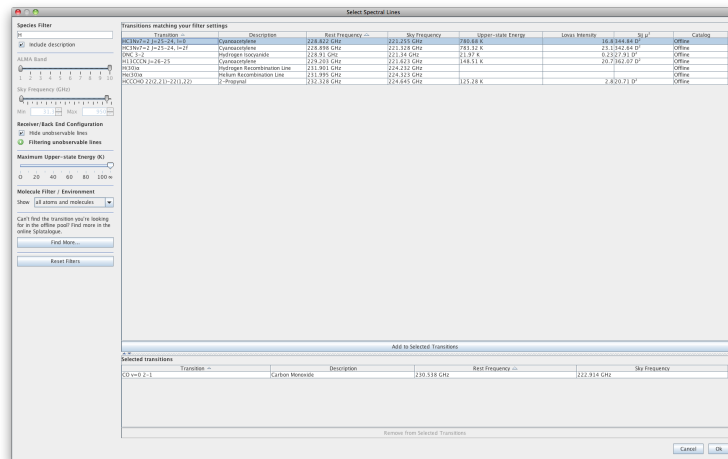

Figure 3.2: The ALMA Spectral Lines Selection Tool.

- **Species Filter**: Text string for selecting the transitions. Note that quantum numbers are ignored. The description fields can be searched at the same time and this is enabled by default.

- **Frequency Filters**:

  - **ALMA Band**: To search in the selected ALMA bands.
  - **Sky Frequency**: Search in a certain frequency range. The range can be defined more precisely using the `Min` and `Max` fields.

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- **Receiver/Back End Configuration**: If enabled, only lines will be displayed that could be observed with any others spws that have already been selected i.e. it checks to see that all lines can fit in the receiver sidebands.

- **Maximum Upper-state Energy**: This filter sets the maximum energy level of the upper state of the transition.

- **Molecule Filter/Environment**: Narrow the candidate molecular transitions by selecting the category of lines to be shown.

- **Find More...**: Also search the on-line catalogue. The lines found are added to the OT's list of available lines, for the duration of a particular OT session.

- **Reset Filters**: Reset the filters to the original values.
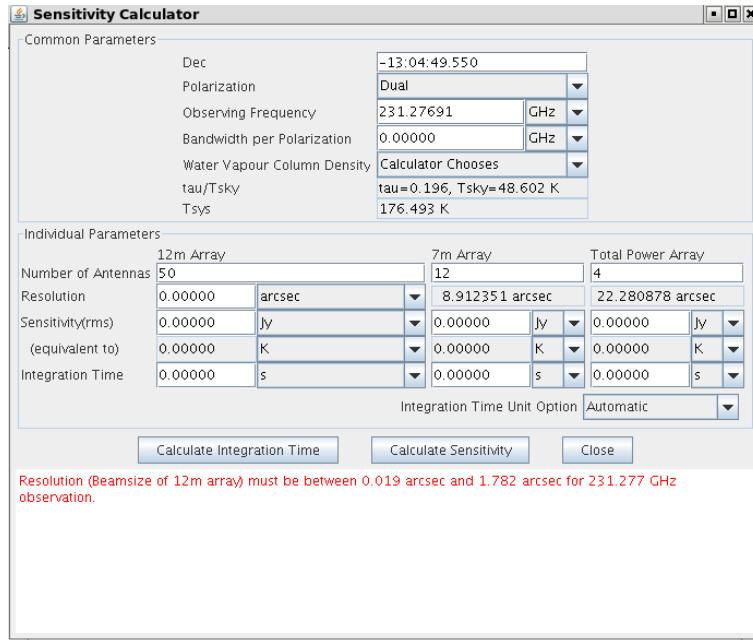
3.3   ALMA Sensitivity Calculator

Figure 3.3: The Sensitivity Calculator.

3.3.1   Common Parameters

- **Dec**: Declination of the target. This gives the source's maximum elevation.

- **Polarization**: Dual or Single polarization.

- **Observing Frequency**: Only frequencies falling within the 10 envisaged ALMA bands are allowed.

- **Bandwidth per polarization**: Bandwidth (frequency resolution) per polarization. Valid range is between 0 and 16 GHz. This value multiplied by the number of polarizations gives the effective bandwidth.

- **Water Vapour Column Density**: Precipitable water vapour column density in mm. A number of standard values can be selected or these can be automatically determined by the OT based on the observing frequency.

- **tau0/Tsky**: Displays the zenith opacity and sky temperature (at the target's maximum elevation).

- **Tsys**: Displays the derived system temperature.

3.3.2   Individual Parameters

- **Number of Antennas**: The maximum number of antennas per array.

- **Resolution**: Desired angular resolution.

- **Sensitivity (rms)**: Requested/derived sensitivity. May be specified in Jy or K. Note that using the Alt key when changing the unit choice will perform a conversion of the value. Also displayed are the equivalent values of sensitivity, in K or Jy.

- **Integration Time**: Requested/derived integration time. This only includes the time on source – no overheads e.g. for calibration, are included.

3.3.3   Buttons

- **Calculate Integration Time**: Calculate observing time based on the system setup and the desired sensitivity.

- **Calculate Sensitivity**: Calculate sensitivity based on the system setup and the desired integration time.

- **Close**: Close the GUI.

3.4   LO Configuration Tool

This tool allows the user to experiment with baseband and LO setups, independently of the OT spectral setups. It acts as a user interface to the LO Solutions software that is used to calculate the tuning solutions for SBs and Science Goals. It is not recommended for anyone other than expert users.

3.4.1   Hardware Info

This panel provides information about the hardware for the various Bands.

3.4.2   Settings

- **Receiver Type**: Select the desired receiver/receiver type. The details of the receiver bands are provided at the top of the display.

- **Request LO1**: If the check box is selected then a specific LO1 may be entered.

- **SSB or DSB Baseband Specs**: Up to 4 basebands may be added and the following items entered for each:

  - **Sideband Pref**: Preferred sideband. Choose between LSB, USB, either (in which the system will make the choice), or both (only for the case of DSB receivers i.e. Bands 9 and 10).
  - **Sky Frequency**: The desired sky frequency.
  - **Weight**: A weighting for this side band selection to apply when calculating the LO setup.
  - **IF Frequency**: A suggested IF frequency calculated on the basic of the sky and LO1 frequencies (not guaranteed).
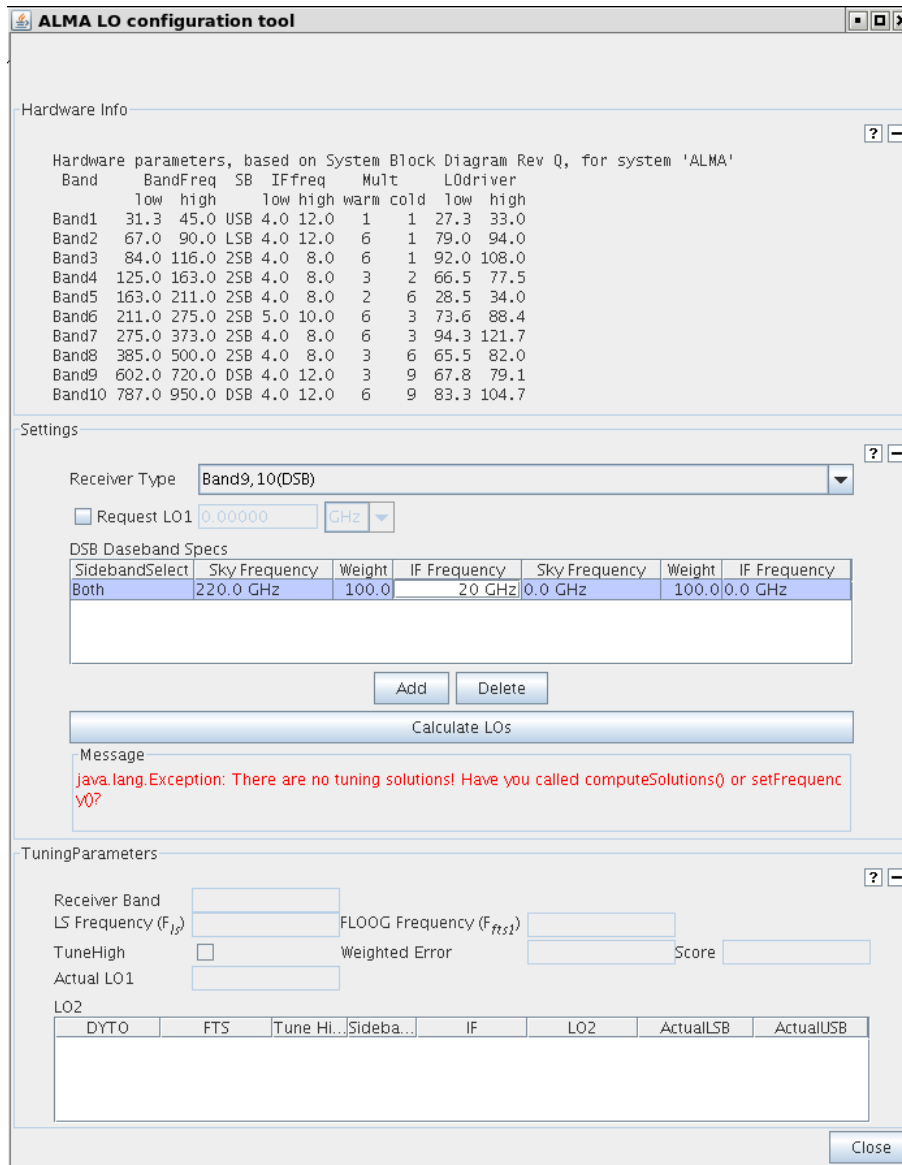
Figure 3.4: The LO Configuration Tool.

3.4.3 TuningParameters

- **Receiver Band**: The OT notation of the receiver type cartridge that will be used.

- **LS Frequency**: The Laser synth frequency.

- **FLOOG Frequency**: The First LO Offset Generator (FTS1) frequency.

- **TuneHigh**: Tick the box if the FLOOG frequency is added to the first LO frequency

- **Weighted Error**: The weighted sum of the abs(actual - requested) frequency over all basebands. This is one measure of the goodness of the tuning.

- **Score**: This is a measure of the relative desirability of the tuning.

- **Actual LO1**: The actual LO1 frequency that will be used.

- **LO2 Table**:

- **DYTO**: Digital YIG Tuned Oscillator.
- **FTS**: Fine Tuned Synthesiser.
- **Tune High**: See above.
- **Sidebands**: The sideband that is used.
- **IF**:The Intermediate Frequency.
- **LO2**: The LO2 frequency.
- **Actual LSB**: Actual frequency of the LSB.
- **Actual USB**: Actual frequency of the USB.

3.5 Calibration Time Estimate Tool

The tool allows the user to calculate the observing time required for the calibration target, based on various parameter settings. It is assumed that the tool will be used by advanced users mainly.

The tool contains two panels, Calibration Time and Cycle Time. At the top the **Calibration Type** has to be specified: the choices are identical as for the the Calibration Selection Tool. The various fields are listing below.

3.5.1 Calibration Time

- **Source Name**: Name of the source.
  - **Resolve**: Resolve the name using a catalogue.
  - **System**:Coordinate system type.
  - **Sexagesimal display**: Display in sexagesimal coordinates.
  - **RA**: RA coordinate.
  - **Dec**: Dec coordinate.
- **Calibrator**: Name of calibrator.
  - **Resolve**: Resolve the name using a catalogue.
  - **System**:Coordinate system type.
  - **Sexagesimal display**: Display in sexagesimal coordinates.
  - **RA**: RA coordinate.
  - **Dec**: Dec coordinate.
- **Calibrator Flux**: Expected calibrator flux.
- **Offset Angle**: Offset angle from the source to the calibrator.
- **One way movement**: Antenna movement time in seconds (one way). Rough estimate = angle/3.0 [deg/sec] + 1.5 [sec].
- **Centre Frequency**: Observing frequency.
- **Water Vapour**: Maximum allowed column density of the precipitable water vapour.
- **Desired SNR**: Desired signal-to-noise ratio.
- **Number of Antennas**: Number of antennas.
- **Aperture Efficiency**: Aperture efficiency.
- **Tsys**: System Temperature.

- **Resolution (Obs)**: Spectral resolution of the target observation.

- **Resolution (Cal)**: Spectral Resolution of the calibrator observation.

- **Calibration Time**: Estimated calibration time per calibrator.

- **Total Time**: Total observing time for the calibration (on target + two-way movement).
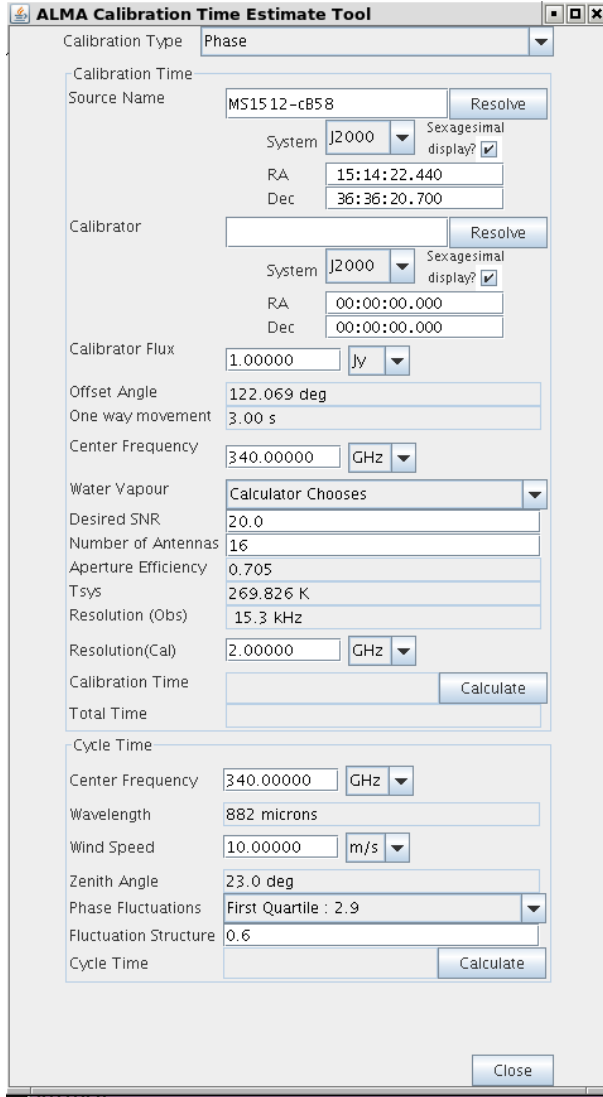

Figure 3.5: The Calibration Time Estimate Tool.

3.5.2 Cycle Time

- **Centre Frequency**: Observing frequency (centre).

- **Wavelength**: Wavelength at the centre frequency.

- **Wind Speed**: Wind speed.

- **Zenith Angle**: Zenith angle of the calibrator at the meridian.

- **Phase Fluctuations**: Phase fluctuations (in degrees). Weather dependent.

- **Fluctuation Structure**: Exponent of the Fluctuations' Structure function. Meridian value is AOS = 0.6.

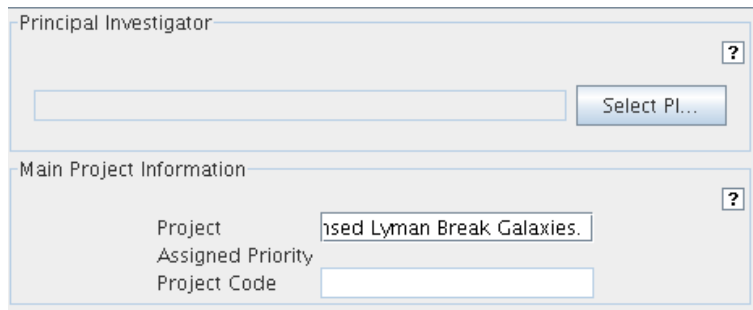- **Cycle Time**: Apply the *Calculate* button to estimate the time.

Chapter 4

The Phase 1 Proposal: Basic Details

To submit a proposal to ALMA, it is necessary to provide a number of administrative details, before going on to define one or more Science Goals. The former are covered in this chapter, whilst Science Goals are discussed in Chapter 5.

The Project node (common to both Phase 1 and 2) contains the Principal Investigator and Main Project Information panels, with the following fields:

- **Select PI...**: Select the Principle Investigator from the list of registered ALMA users.

- **Project**: Title of the project.

- **Assigned Priority**: Not yet used.

- **Project Code**: A unique code for the project, assigned automatically upon its first submission.

Figure 4.1: The Project node panels.

4.1   Proposal Information

- **Proposal Title**: A title for the proposal.

- **Proposal Cycle**: The current proposal cycle – set automatically upon first submission.

- **Abstract**: A short abstract for the proposal. Limit of 4000 characters.

- **Proposal Type**: The type of the proposal. Currently only Standard (<100 hours) and Target of Opportunity are available.

- **Scientific Category**: A set of radio buttons for selecting the proposal's science category.

- **Keywords**: Assign a maximum of two keywords to the project.

- **Student Project**: Check the box if the proposal concerns a PhD or other major student project.

- **Continuation**: Check the box if this is a continuation of a previous project.

- **Related Proposals**: Proposals to ALMA from this Cycle that are related to the current project. Project code, title and PI name should be given.

- **Previous Proposals**: Details of any related ALMA proposals from previous Cycles. Project code, title and PI name should be given.
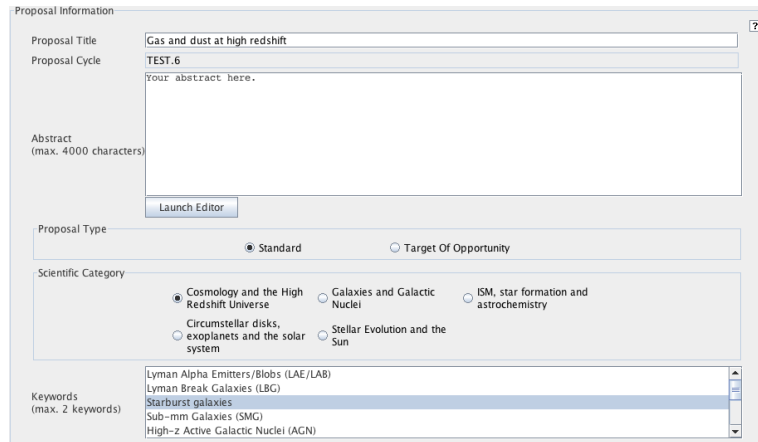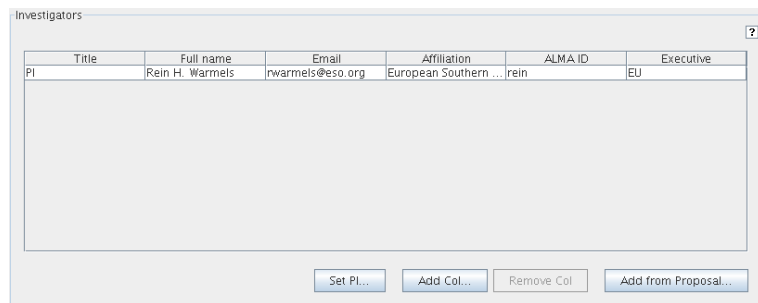

Figure 4.2: The Proposal Information Panel.

This contains basic information about the proposal.

4.2 Investigators

This contains information about the proposal investigators. All investigators must already be registered with ALMA via the Science Portal. The Principal Investigator is required and one or more Co-Investigators may also be added.

Figure 4.3: The Investigators panel in the proposal Forms editor.

For each investigator the following details are required:

- **Type**: Is this a PI or a co-I?

- **Full Name**: Full name of the investigator as stored in the ALMA user database.

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- **Email**: The email address of the investigator.

- **Affiliation**: The affiliation/institute of the investigator.

- **ALMA ID**: This is the username used to access the Science Portal.

- **Executive**: This determines how a project's time will be "charged". Taiwanese users can choose between EA and NA. For everyone else, this is fixed to the value entered in the Science Portal.

The buttons below the panel can be used to complete the table of investigators:

- **Set PI**: To fill in the PI data by accessing the ALMA user database.

- **Add CoI**: To fill in the co-I data.

- **Remove CoI**: To delete a highlighted Co-I from the table. Note that PI's can only be changed, not deleted.

- **Add from Proposal...**: Opens a window to select an ALMA Proposal and to append its users to the current project.

4.3   Science Case and Supporting Documents

In this section, the mandatory science case can be added to the proposal. Note that the format must be PDF and have a maximum of five pages. It must include a description of the project's technical requirements.

The buttons are:

- **Attach**: This will launch a file browser dialogue to allow the user to choose the PDF file.

- **Detach**: This will remove a previously attached file from the proposal.

- **View**: This will ask the desktop operating system to launch a viewer to display the document. *Note:* this relies on the operating system being setup and an appropriate application installed.

4.4   Observatory Use Only

This section contains proposal information that is used by observatory staff only.

Chapter 5

Phase 1 and Phase 2 Science Goals

Science Goals are designed to capture the scientific aims of a particular observation i.e. the technical details of the observations are hidden from the user. These are contained within the Scheduling Blocks which can be automatically generated from the information contained within the Science Goal.

Clicking on the top node of a Science Goal will display either a Science Goal summary table is or all of the Forms editors, depending the user preferences. Descriptions of the five Science Goals Forms editors (General, Field Setup, Spectral Setup, Calibration Setup and Control and Performance) follow.

5.1   General

This General form is to provide the title and the description of the Science Goal. Both are optional.

5.2   Field Setup

In the Field Setup form, the user is asked for target parameters such as the name, coordinates, velocity and proper motion. Either multiple pointings or a single rectangle (that will be automatically mosaiced) can be defined.

The bottom of the form shows four buttons that control the source list:

- **Add Source**: Add a science source, the details of which can either be "resolved" or added manually.

- **Load from File...**: Add one or more sources, including their properties, using a local ASCII file.

- **Delete Source**: Delete a source.

- **Delete All Sources**: Delete all sources.

5.2.1   Source

- **Source Name**: The source name. The source names should only contain the following characters: a-z, A-Z, 0-9, -,+, _ or a . (full stop). Characters other than these will be removed or replaced when the project is validated. Clicking on "Resolve" will search for this source using either the SIMBAD or NED servers and will fill in the source properties if a match is found. Check the details very carefully!

- **Resolve**: Query the servers using the entered source name.

Figure 5.1: The Source panel in the Field Setup form of the Science Goal.

- **Choose a Solar System Object**: A number of solar system objects are recognised by the telescope control system and can be selected here. It is also possible to enter an ephemeris for any non-sidereal source.

- **Name of Object** Recognised objects are:
    - Stars: The Sun.
    - Planets: Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune.
    - Satellites: The Moon, Ganymede, Callisto, Io, Titan.
    - Dwarf planets: Pluto, Ceres.
    - Asteroids: Pallas, Juno and Vesta.
    - Ephemeris: Load a JPL HORIZONS format ephemeris.

- **Source Coordinates**: Includes the system – J2000 should be chosen.

- **RA**: Source Right Ascension.

- **DEC**: Source Declination.

- **Parallax**: Source parallax.

- **PM RA**: Proper motion in the R.A. (cross-declination) direction. Units should be milliarcsec/yr. Proper motions are used to calculate the current source position assuming that the J2000 position refers to Epoch J2000.

- **PM DEC**: Proper motion in the declination direction; Units should be milliarcsec/yr.

- **Source Velocity**: The velocity (or redshift) of the source, including the units, reference frame and Doppler convention (radio, optical or relativistic).

- **Target Type**: The supported observing patterns: "Multiple pointings" and "1 rectangular field". Only one source per Science Goal is allowed if a rectangular field is defined.

5.2.2 Expected Source Properties

One of the reasons for providing this information is to aid in technical assessment. All relevant items should be filled in.

- **Peak Continuum Flux Density per Beam**: The expected flux density per beam of the source continuum.

- **Peak Line Flux Density per Beam**: The expected peak flux density per beam of the line emission.

- **Polarisation Percentage**: The expected degree of polarization for the source.

- **Line Width**: The expected line width for the lines in this Science Goal.

Figure 5.2: The Expected Source Properties panel in the Field Setup form for the Science Goal.

5.2.3 Field Center Coordinates

This panel is visible if Multiple Pointings have been selected in the Source panel.

- **PointingPattern**: Field centre in absolute or relative coordinates. Offsets are determined with respect to the source coordinate.

- **Offset Unit**: Select the units for the offset.

- **RA**: Absolute coordinate of the centre of the pattern or the offset from the field centre in Right Ascension.

- **DEC**: Absolute coordinate of the centre of the pattern or the offset from the field centre in Declination.

Figure 5.3: The Field Centre Coordinates panel for the case of multiple pointings.

5.2.4 Rectangle

This panel is only visible when "1 rectangular field" is selected in the Source panel.

- **Coords Type**: Field centre in absolute or relative coordinates. Relative positions are offset from the source coordinate.

- **Field Centre Coordinates** (Absolute)

  - **System**: Coordinate System.
  - **Sexagesimal display**: Check to switch between the coordinates formats.
  - **RA**: The centre coordinate of the rectangle in Right Ascension.
  - **DEC**: The centre coordinate of the rectangle in Declination.

- **Field Centre Coordinates** (Relative)

  - **Offset(Longitude)**: Longitude offset of the centre of the rectangle from the source coordinate.
  - **Offset(latitude)**: Latitude offset of the centre of the rectangle from the source coordinate.

- **p length**: Length of one side of the rectangle.

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- **q length**: Length of the other side of the rectangle.

- **Position Angle**: Position angle of the "p" side of the rectangle from the vertical direction.

- **Spacing**: Spacing of the data required within the rectangle. Can be specified in arcmin or in fraction of the antenna beam. Nyquist spacing is the default.

- **Reset to Nyquist**: Reset the spacing to the Nyquist sampling.

- **Export**: Export the pointings (12-m and 7-m array) to disk.

Figure 5.4: The Rectangle panel of a Science Goal's Field Setup.

5.3   Spectral Setup

This contains fields to specify spectral setup parameters. The Forms editor basically consists of two panels for the spectral specification and a feedback area that gives messages when the spectral specs are in error.

- **Spectral Type**: The kind of spectral type observations. Choices are: "Spectral Line, "Single Continuum", or "Spectral Scan", although the latter is not yet supported. The display in the next panel is configured depending on the selected option. When selecting "Spectral Line" a table to contain the spectral windows is displayed.

- **Polarization**: Options are XX or DUAL (XX and YY), where X and Y are the linear orthogonal polarizations detected by the ALMA receivers.

5.3.1   Spectral Type

Figure 5.5: The Spectral Type panel in the Science Goals Spectral Setup.

5.3.2 Spectral Type Details

5.3.2.1 Spectral Line

Four panels for the four basebands will be visible and one spectral window can be added to each. Adding a spectral window is done either by selecting spectral lines from the spectral line catalogue or by adding them manually. One of the spectral windows should be selected as that which will set the Representative Frequency. This defaults to the centre of the spectral window, but can be changed at the bottom of the page. This sets the size of the antenna beams drawn in the Visual Spatial Editor and is also used to work out the time estimate for the Science Goal.

- **Select Lines to Observe in BaseBand...**: Opens the Spectral Line Selection Tool allowing a huge list of transitions to be searched.

- **Add**: Add a blank row to the table that can then be completed manually.

- **Delete**: Delete the selected row from the table.

Figure 5.6: The spectral window table for a single baseband.

The spectral window table has the following columns. Most accept input by being double-clicked.

- **Fraction**: Indicates what fraction of the available correlator hardware this spectral window should use. This is currently fixed to "Full" i.e. 100%.

- **Centre Freq Rest**: The centre rest frequency of the window.

- **Centre Freq Sky**: The centre sky frequency of the window.

- **Transition**: A standard name for a spectral line transition, usually entered by the Spectral Line Selection Tool. Any label that is useful to the user can be entered here, but standard ASCII characters should be used.

- **Bandwidth, Resolution**: The bandwidth and spectral resolution of the window – each equals a correlator mode. Only allowed modes may be chosen from a drop-down list. The resolution is calculated assuming Hanning smoothing i.e. twice the channel spacing. This is applied by default to all data. The correlator modes in bold font have lower resolution and can be used to observe continua or broad spectral lines.

- **Representative Window**: Select one of the spectral windows to set the Representative Frequency.

5.3.2.2 Single Continuum

This allows a maximum bandwidth setup to be defined using only a single frequency. This can be entered in rest-frame or observed-frame units, but observed (sky) is the usual choice. A low-resolution correlator mode is chosen for each spectral window.

- **Input Frequency Type**: Frequency type to be specified. Whichever is chosen, the equivalent is also shown (calculated using the velocity of the first source in the Science Goal).

- **Rest Frequency**: Enter a frequency in the rest-frame of the source.

- **Sky Frequency**: Enter a frequency in the observed (sky) frame.

Figure 5.7: The Single Continuum panel in the Science Goals Spectral Setup.

Figure 5.8: The Science Goal Calibration Setup Forms editor.

5.3.2.3 Representative Frequency

The value of the Representative Frequency is displayed here. This will default to the centre of the chosen spectral window, but can be changed to another frequency within that spectral window if the transition of greatest interest is not at the centre.

5.3.2.4 Spectral Scan

This option is not supported yet.

5.3.2.5 Spectral Setup Errors

This panel will displays errors and warnings for the spectral specifications, if any. Note that not all are shown – additional ones may appear upon validation.

5.4 Calibration Setup

In this Forms editor, the user can specify how to calibrate the data. Almost all proposals should request "system-defined" – the observatory will ensure that suitable calibrators are observed. The available choices are:

- **System-defined calibration**: The system will decide on the calibrators and the calibration strategy.

- **User-defined calibration**: When checked, the calibration table is enabled with the following buttons:

  - **Add Dynamic Calibrator...**: Set some constraints that will be used to dynamically select a suitable source at SB execution time.
  - **Add Fixed Calibrator...**: Choose a specific calibrator source.

– **Delete Selected Calibration**: Delete a selected row in the calibration table.

In the table with the Calibration types, use the **Edit Criteria...** button to edit the search criteria to be used for the calibration selection. It is **STRONGLY** suggested to choose system-defined calibration!

5.5   Control and Performance

One panel at the top of the page shows array and telescope configuration information. This should be used to guide a user in the choice of parameters in the panel below, that control predominantly the time required and whether the ACA is required.

Figure 5.9: The Science Goal Control and Performance parameters.

The configuration information (all calculated assuming the sky-frame equivalent of the Representative Frequency for the first source in the Science Goal) are:

- **Antenna Beamsize**: Display of the antenna beam size for the 12- and 7-m dishes.

- **Longest baseline**: The maximum baselines available for the most compact and extended configurations.

- **Synthesized beamsize**: The synthesised beam sizes for the corresponding maximum baselines.

- **Shortest Baseline**: The minimum baselines available for the most compact and extended configurations.

- **Maximum recoverable scale**: The largest scale structures that it is possible to image with the most compact and extended configurations.

The user-entered parameters are the following:

- **Desired Angular Resolution**: The desired angular resolution (synthesized beam size). Must be between the best resolution achievable (i.e. with the most extended configuration) and twice that achievable with the most compact configuration. The latter allows a modest amount of smoothing during data reduction. Based on this value, the OT will choose an appropriate 12-m array configuration.

- **Largest Angular Structure in source**: The angular extent of the largest components in the source that need to be imaged.

- **Desired sensitivity**: The sensitivity aim for each source. If a rectangle has been defined, this value should be what is desired in the final mosaic i.e. including beam overlaps. For "multiple pointings", it is the value per pointing.

- **Bandwidth used for Sensitivity**: Specify which bandwidth should be used to calculate the time required. This is used in conjunction with the desired sensitivity and the Representative Frequency. A number of shortcuts are possible (FinestResolution, AggregateBandWidth, LargestWindowBandWidth) or a user-defined value can be entered. "FinestResolution" corresponds to twice the channel spacing i.e. Hanning smoothing is assumed.

- **ACA**: Based on the user-entered values of largest angular scale and angular resolution, the OT will suggest whether the ACA is required and set the choice automatically. Changing this must be well justified and is not recommended. Note that the ACA cannot be chosen if the two largest configurations (C32-5 and C32-6) are required – which configuration has been chosen by the OT is also reported in this dialogue.

- **Time Estimate**: At this point, it is possible to request an estimate of how long it will take to achieve the scientific objectives of the Science Goal. This brings up a dialogue that contains a lot of information about the times required and parameters used in their derivation. The times reported include calibration and overheads (hardware and software). The ACA observing time is set to three times that required for the 12-m array.

- **Extra time**: For observations where sensitivity is not the main goal i.e. flux monitoring, the need for a particular amount of observing time can be indicated here. The amount of time and justification should be given in the scientific and technical case.

- **Constrained time**: Projects that require particular that the data be observed at particular times can be described here. A basic calendar tool is available.

Chapter 6

Phase 2 Program Scheduling Blocks

Planning of an Observing Program can be done in great detail by defining the Phase 2 Observing Unit Sets and Scheduling Blocks. Comprehensive information how to do this can be found in the OT User Manual Chapter 8: Phase 2 Program Scheduling Blocks.

6.1 Observing Unit Set

The Observing Unit Set contains one or more Scheduling Blocks and defines the relationships between these SBs.

6.1.1 Basics

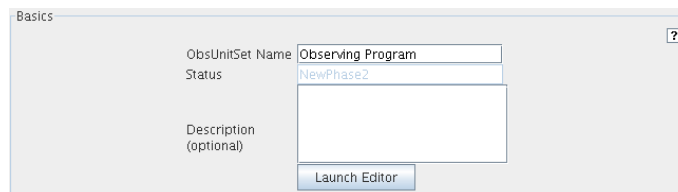The *Basics* panel contains very basic none-technical information only.

Figure 6.1: The *Basics* panel of Observing Unit Set form

- **ObsUnitSet Name**: A user entered name for this OUS - to be used for mnemonic purposes.

- **Status**: This item should probably be removed; it is intended that mutable information, in particular the status of various pieces of the Observing Project, be maintained in the independent scheduling/project status tree.

- **Description**: Optional description of the Observing Unit Set

- **Launch Editor**: Enable a special window of editing the Description.

6.1.2 Control

The *Control* panel provides the execution control limits for the OUS, in terms of items like the maximum time allowed, the user and scheduling constraints.
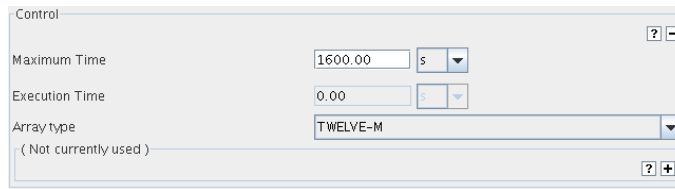
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Figure 6.2: The *Control* panel of Observing Unit Set form

- **Maximum Time**: This is the sum of allowed execution times for all parts of this OUS. It will accumulate the maximum times of all other OUSs and SBs below it in the hierarchy.

- **Execution Time**: This is the estimated actual execution time as calculated by the OT.

- **Array Type**: The array configuration to be used. Options are the 12-m Array, the ACA, the 7-m Array and the Total Power Array.

The following fields are currently not used:

- **User Priority**: This is assigned by the user to this OUS. It should perhaps be associated only with Scheduling Blocks rather than with (additionally) OUS, but applying to the latter might provide a convenience for recursion.

- **TAC Priority**: Priority of this observing unit as set by the TAC. Perhaps should only apply to SBs, but at the OUS level might provide a convenient mechanism for recursion.

- **Pointing Accuracy**: The desired pointing accuracy as the outcome of this calibration.

- **Bandpass Accuracy**: The bandpass calibration must be accurate to this level - deviation from the mean, expressed as a fraction.

- **Polarization Accuracy**: Polarisation must be calibrated to this level - probably expressed as a fraction.

The following three panels *Unit Dependencies*, *ObsUnitSet*, *Data Processing* panels are currently not used.

6.2   The Scheduling Block

The Scheduling Block are the key executable units of a project and contains all information necessary to execute a single observation. In addition to the SB overview form itself, SB target details are stored in Field Sources, Instrument Setup and Observing Parameters forms.

The panels *Unit Dependencies* and *Temporal Constraints* in the SB form are currently not used and the fields in these panels are not listed below.

6.2.1   Basic

- **SchedBlock Name**: A user entered name for this SB - to be used for mnemonic purposes.

- **Status**: This item should probably be removed; it is intended that mutable information, in particular the status of various pieces of the Observing Project, be maintained in the independent scheduling/project status tree.

- **Description**: Optional description of the SchedBlock.

- **Launch Editor**: Enable a special window of editing the Description.

Figure 6.3: The *Basics* panel of the Scheduling Block form

6.2.2 Control

The *Control* panel provides the execution control limits, in terms of items like the maximum time allowed, the user and TAC priorities etc.

Figure 6.4: The *Control* panel of the Scheduling Block form

- **Maximum Time**: This is the sum of allowed execution times for all parts of this SchedBlock. This will be = repeatCount*SBMaximumTime;

- **Execution Time**: This is the estimated actual execution time as calculated by the OT.

- **Array Type**: The array configuration to be used. Options are the 12-m Array, the ACA, the 7-m Array and the Total Power Array.

In the next subpanel the following fields are currently not used:

- **User Priority**: This is assigned by the user to this SchedBlock. Perhaps it should be associated only with Scheduling Blocks rather than with (additionally) OUS, but applying to the latter might provide a convenience for recursion.

- **TAC Priority**: Priority of this SB as set by the TAC. Perhaps should only apply to SBs, but at the OUS level might provide a convenient mechanism for recursion.

- **Pointing Accuracy**:The desired pointing accuracy as the outcome of this calibration.

- **Bandpass Accuracy**: The bandpass calibration must be to this level - deviation from the mean, expressed as a fraction.

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- **Polarization Accuracy**:Polarisation must be calibrated to this level - probably expressed as a fraction.

6.2.3 Preconditions

The *Preconditions* panel specifies the conditions that must be met before this SchedBlock can be executed.

Figure 6.5: The *Preconditions* panel of the Scheduling Block form
.

- **Baseline cal**: If true, baseline calibration must have been done before this SB is executed.

- **Max PWVC**: Maximum value of precipitable water vapour column density in mm. If the current value exceeds this, the SB should not be executed.

- **Seeing**: The user will want to input this in arc seconds. This should be the raw value (i.e., before correction).

- **Phase Stability**: RMS of astronomical phase after WVR correction over some TBD time period (hopefully >= length of an SB), expressed in degrees.

- **Max Wind Velocity**: Maximum allowed wind velocity for this SB.

- **Min Allowed HA**: SB must be scheduled at HA greater than this maximum.

- **Max Allowed HA**: SB must be scheduled at HA less than this minimum.

6.2.4 SchedBlock

- **Standard Mode**: Checkbox. If true, this SchedBlock is part of a supported, "standard ALMA observing mode", such as single-field interferometry or interferometric mosaicing. This field will be set to false by the Observing Tool should a user intervene directly in the OUS/SB hierarchy, rather than relying on the OT's generated values that are derived from his/her scientific input.

- **Mode Name**: The name of the (presumably standard) observing mode, e.g., SingleFieldinterferometry, OpticalPointing.

- **Mode Type**: The type of the observing mode: either a Standard mode, User or Observatory, or a non-standard Expert mode.

- **Execution Count**: The number of times to execute this SB. (I.e., execution count = 0 –> SB will never be run and is an invalid value).

Figure 6.6: The *SchedBlock* panel of the Scheduling Block form

- **Max. Time**: Maximum time for a single execution of this SB.

- **Obs. Procedure**: The script (written in Python) that contains the observation logic to be executed by the Control subsystem for this Scheduling Block. For standard observing modes, this script will be obtained from a configuration-controlled library that is managed by the ALMA observatory. At execution time, all parameters contained in the Scheduling Block will be made available to this script.

- **Run Quick Look**: Checkbox. Indicates whether or not the Quick Look should execute on completion of this SB. For most science uses this will be true, but for some engineering or calibration SBs it may be false. In general the value should be determined by the observing mode with rare need for user-override.

6.2.5 Performance Goals and Scheduling Constraints

The *Performance Parameters* panel define the science performance required for this SB.

Figure 6.7: The *Performance* panel of the Scheduling Block form

- **Representative Target**: The representative target, to be used partly for more information about the required observing conditions, but mostly to indicate which target to measure the observing goals against.

- **Representative Coordinates**: The representative coordinate for this SB. Usually obtained from the representative target, but may be derived by some other algorithm for some types of SB. **Systems** gives a drop down menu to specify the coordinate system. **Sexagesimal display** is to specify the notation format.

- **Representative Frequency**: The frequency to be used when considering (setting up for or measuring) the performance goals identified for this science goal.

- **Representative Receiver Band**: Representative receiver band for this SB execution.

- **Min. Angular Resolution**: This parameter, its twin, "Max Angular Resolution," and the Representative Frequency are used by the Scheduler to determine whether the current antenna configuration is suitable to achieve the angular resolution desired by the PI.

- **Max. Angular Resolution**: see above.

- **Dynamic Range**: This is the ratio of maximum flux expected to rms level desired; it may apply either to a particular spectral window or as a minimum goal for all windows. It affects the uv-coverage necessary as well, and hence is needed by the Scheduler.

6.3   Observing Groups

Each target (see below) must be placed into an observing group for it to be observed. (There are exceptions for certain observatory calibration modes). Groups are added from the Edit menu, and targets are allocated to groups in the editor for the Observing Group.

6.4   Targets

For each target the Resources are to be defined: Field Source, Instrument Setup, Observing Parameters. These details are stored in the corresponding subfolders in the Resource folder. Combining these details reveals the complete target description that are visible with clicking on the targets in SB Target folder. A table overview of the targets is displayed when selecting the SB Targets node in the Project Tree.

Below follow the detailed descriptions for the Field Sources, Instrument Setup, Observing Parameters forms.

6.5   Resources

6.5.1   Field Sources

A table overview of the Field Sources is displayed when selecting the SB Field Source node in the Project tree. The following panels are visible for each Field Source node.

6.5.1.1   Field Source

- **Field Source Name**: A user-settable name for the Field Source - allows the user to identify a particular setup. This name can be different from the source name, e.g. "NGC1068 nucleus".

- **Source Name**: The source name. Typically obtained from a catalogue.

- **Choose a Solar System Object**: Check if source is solar system object. The drop down list contains known (to the control system) solar system objects. "Ephemeris" is a special choice, for which the "ephemeris" attribute should be completed.

- **Source Coordinates**: The coordinates of the source. This item includes

Figure 6.8: The *Field Source* Panel of the Scheduling Block Field Sources Form
.

- **System** to specific the coordinates system
- **Sexagesimal display** for the format.
- **Parallax**: Parallax angle for the source.
- **RA** and **Dec**. Typically might be obtained from a catalogue.
- **Proper Motion RA**: Proper motion in right ascension; typical units are milliarcsec/yr. Might be obtained from catalogue.
- **Proper Motion Dec**: Proper motion in declination; typical units are milliarcsec/yr. Might be obtained from catalogue.

- **Source Radial Velocity**: The velocity of the source, including reference frame, optical or radio measurement and the redshift. It is also possible to enter a redshift. Might be picked up from catalogue.

In the source properties table that follows frequency, flux and diameter can be provided.

Finally:

- **Visible Magnitude**: Visible magnitude for the source (used in optical pointing). Is this definitely used/required? If so, can we specify it a little better?

- **Use Reference**: Use this position as a reference for off-source single dish observation.

6.5.1.2 Reference Position (Offset)

In case the **Use Reference** box is tagged, up to two reference positions can be specified.

Figure 6.9: The *Reference Position, Field Pattern* panel in the Schedblock Field Source Form

- **Coords Type**: Field centre(s) in absolute or relative coordinates. In case `Absolute` is selected the specifications for the field centre need to be provided. In case `Relative` the offset from the source coordinate shall be provided.

- **Reference Coodinates**: Coordinate System (ABSOLUTE only).

- **RA**: Absolute field centre coordinate (RA) (ABSOLUTE only).

- **DEC**: Absolute field centre coordinate (Dec) (ABSOLUTE only).

- **Offset[RA]**: RA offset from the source coordinate (RELATIVE only).

- **Offset[DEC]**: DEC offset from the source coordinate (RELATIVE only).

- **Integration Time**: This is the time spent off-source in a single dish observation.

- **Cycle Time**: This is the period between visits to the reference position.

- **Sub Scan Duration**: The number of seconds the sub-scan will take. This value must be an multiple of the integration duration.

- **Adjust subscan duration to a correct value**: Adjust the sub scan duration to fulfil thr requirements.

6.5.1.3 FieldPatternEditor

In the *Field Pattern* panel the field pattern can be defined. The choice of the field pattern determines the name and the fields in the next panel in which the properties of the field pattern are to be defined.
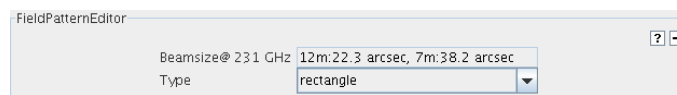

Figure 6.10: The upper part of the *Field Pattern* panel of the SchedBlock Field Source Form

At the top the primary beamsizes at 230 GHz for the 12-m and 7-m are displayed.

- **Type**: The pattern to be used in observing the target, be it scientific or calibration. Supported are `point`, `rectangle`, and `cross`.

6.5.1.4 Field Pattern

Below follows the field and the description of the various field patterns:
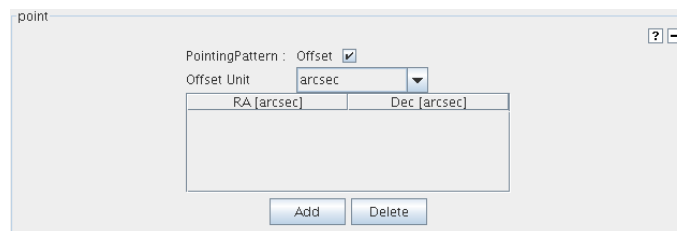
- For **Point**:

Figure 6.11: The field pattern *point* panel for the Scheduling Block Field Source Form

  - **PointingPattern: Offset**: Tick if the pointing pattern position is an offset w.r.t. the source. If not ticked absolute positions are provided.
  - **Offset Unit** (Type=point): Units of the offset (only if `Offset` is ticked).
- For **rectangle**:

Figure 6.12: The field pattern *rectangle* panel for the Scheduling Block Field Source Form

- **Coords Type**: Field centre in absolute or relative coordinates. In case `Absolute` is selected the specifications for the field centre need to be provided. In case `Relative` the offset from the source coordinated shall be provided.
- **Pattern Centre Coords**
  * **System**: Coordinate System (ABSOLUTE only).
  * **RA**: Absolute field centre coordinate(RA) (ABSOLUTE only).
  * **DEC**: Absolute field centre coordinate(Dec) (ABSOLUTE only).
  * **Offset[RA]**: RA offset from the source coordinate (RELATIVE only).
  * **Offset[DEC]**: DEC offset from the source coordinate (RELATIVE only).
- **Lat. length**: Length of the rectangle in the latitudinal coordinate.
- **Orthogonal step**: Step size in the direction orthogonal to the scan direction.
- **Long. length**: Length of the rectangle in the longitudinal coordinate.
- **Scan Direction**: The scanning direction for the raster, either in longitude or latitude.
- **Unidirectional Scan**: Check if the scan shall always be done is the same direction.
- **Scan Velocity**: The scan velocity.
- **Orientation**: Position angle of the rectangle in the scanning coordinate frame. (Zero point and direction need to be agreed with control).
- **Scanning Coordinate System**: Select the coordinate system.
- **Setup Mosaic (Optional)**: Convert the setup top a pointed mosaic.

• For **Cross**:

Figure 6.13: The field pattern *cross* panel for the Scheduling Block Field Source Form

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- **Pattern Centre Coords**

    * **System**: Coordinate System (ABSOLUTE only).
    * **RA**: Absolute field centre coordinate(RA) (ABSOLUTE only).
    * **DEC**: Absolute field centre coordinate(Dec) (ABSOLUTE only).
    * **Offset[RA]**: RA offset from the source coordinate (RELATIVE only).
    * **Offset[DEC]**: DEC offset from the source coordinate (RELATIVE only).

- **Lat. length**: Length of the cross in the latitudinal coordinate.

- **Long. length**: The length of the cross in the longitudinal direction.

- **Initial Scan direction**: The initial scan direction for the cross.

- **Scan Velocity**: The scan velocity.

- **Orientation**: Position angle of the cross. NOTE: Zero point and direction need to be agreed with Control.

6.5.2 Instrument Setup

When clicking the Instrumental Setup node in the Resources folder of the SB, a summary table becomes visible with Instrument Setups that have been specified.

Below follows the complete list of all fields in the Instrument Setup form for the a SB and their meaning.

6.5.3 Spectral Spec

Figure 6.14: The *Spectral Spec* panel in the SpectralSpec form of the Instrument Setup

- **Spectral Spec Name**: A user-settable name for the Spectral Spec - allows the user to identify a particular setup. Not meant to be used by any subsystem other than Observing Tool.

- **Rest Frequency**: Rest frequency of the line to be observed.

- **Transition**: Molecule and transition.

- **Line Catalogue**: Button to start the Spectral Line Selection tool.

- **Receiver Band**: One of the 10 receiver bands foreseen for ALMA.

- **Receiver Type**: The type of receiver. This should be set automatically, once the receiver band is known. It is one of no sideband (NSB), single sideband (SSB), two sideband (2SB), or dual sideband (DSB).

- **Add Total Power with square law detector to this correlator setup**: Check if in addition to the selected receiver the total power detector with square law detector option shall be used. This option is not implemented yet.
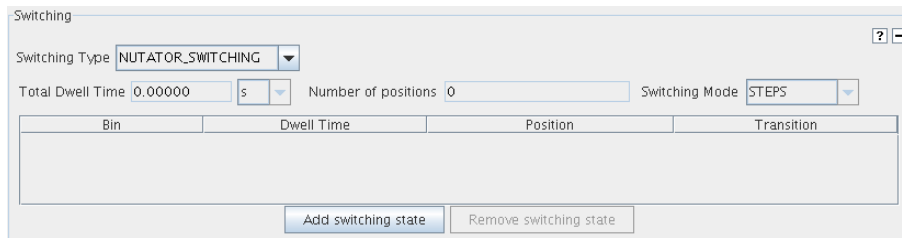
Figure 6.15: The *Switching* panel in the SpectralSpec form of the Instrument Setup

6.5.4 Switching

- **Switching Type**: Type of switching to be used, one of: NO_SWITCHING, FREQUENCY_SWITCHING, and NUTATOR_SWITCHING..

- **Total Dwell Time**: The total time spend on integrating is the total data collecting duration at a given position. For each state the dwell time + dead time must be a multiple of 48 msecs. Dwell time is ignored if there is no switching (TBC).

- **Number of Positions**: The number of switching positions in the switching setup, 1 (which is no switching), 2, 3, or 4.

- **Switching Mode**: To be filled in.

The details for each switching state for the selected type can be entered in the table .
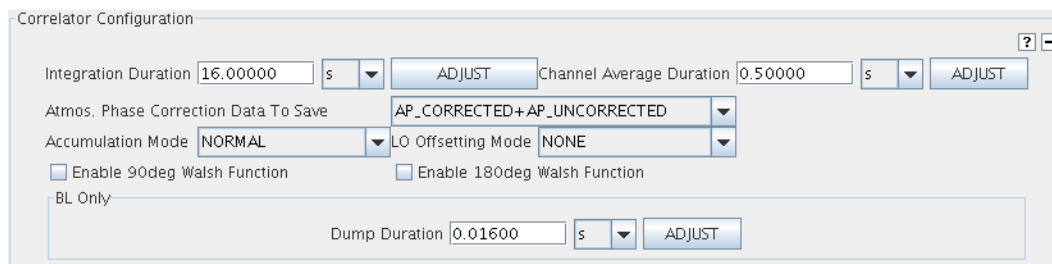
6.5.5 Correlator Configuration

Figure 6.16: The *Correlator Configuration* panel for the ALMA BL in the SpectralSpec form of the Instrument Setup. The panel for the ACA correlation looks very similar.

- **Integration Duration**: The Integration Duration must be a multiple of the Channel Average Duration.

- **Adjust**: Button to force the Integration Duration to be a multiple of the Channel Average Duration.

- **Channel Average Duration**: For the 64-input correlator, this must be a multiple of the Dump Duration. The ACA correlator does not have a Dump Duration and thus other restrictions apply. If the Integration Duration is greater than 1008 ms, the Channel Average Duration must be at least 512 ms. Otherwise, the Channel Average and Integration Durations must be equal.

- **Adjust**: Button to force the channel duration to be a multiple of the channel dump duration.

- **Atmos. Phase Correction Data To Save**: Drop-down list to determine which atmospheric phase corrected data should be saved: corrected, uncorrected, both or mixed.

- **Accumulation Mode**: Two choices:

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– ALMA_FAST (1 msec)

– ALMA_NORMAL (16 msec)

These define the correlator chip level accumulation duration. NORMAL must be chosen for cross-correlations, and this is therefore the default. For FAST, only auto-correlation products are sent to the CDP – both are sent for NORMAL.

- **LO Offsetting Mode**: Drop down list for selecting the LO Offsetting.

- **Enable 90deg Walsh function**: Enable 90 deg Walsh function.

- **Enable 180deg Walsh function**: Enable 180 deg Walsh function.

The following field is visible for a spectral specification with the BaseLine correlator.

- **Dump Duration**: The dump interval must be a multiple of 16 msec (if accumulation mode is NORMAL) or 1 msec (for accumulation mode FAST).

6.5.6 BaseBand Configuration

6.5.6.1 LO Setup Preferences

Figure 6.17: The *LO Setup Preferences* panel for the ALMA baseline correlator configuration in the SpectralSpec form of the Instrument Setup. The bottom part of the figure shows the overview table of the specified basebands

- **Sideband(s) to prioritise**: The check boxes for "Sideband(s) to prioritise" provide the possibility to select the side bands to be prioritised in the calculation of the LO setup. Pressing the GO button will calculate the LO setup according to the parameters set by the check boxes.

- **Base band config(s) to prioritise**: The check boxes "Baseband config(s) to prioritise" provide the possibility to select the baseband configs to be prioritised in the calculation of the LO setup. Pressing the GO button will calculate the LO setup according to the parameters set by the check boxes.

- **Doppler Reference**: Drop down list to select the Doppler reference frame.

- **Calculate LOs**: Calculate the LO setup based on the preference set and the source velocity.

- **LO1 Frequency**: The LO1 frequency as determined in the OT, either by the tool itself, or entered by the user. This is an estimate used to help the user in correlator setup - the actual value used will depend on the time of observation.

- **Total Data Rate**: Estimate of the total instantaneous data rate summed over all basebands and based on the current parameter settings.

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6.5.6.2 BaseBand Configuration Forms

A Baseband Configuration summary table (see Fig 6.18) is visible above the baseband specification forms. Apart from a few fields the table also shows the LO2 frequency and the instantaneous date rates that can be expected for each baseband configuration. Note that the LO2 frequency is determined within the OT, by the tool itself. This is an estimate to help the user in preparing a correlator setup - the actual LO2 used may vary depending on the time of observation, and is set by Control at execution time. for specifying the maximal four basebands.

Figure 6.18: The *BaseBand* tabs for the ALMA baseline correlator configuration in the SpectralSpec form of the Instrument Setup. The bottom part of the figure shows the overview table of the specified spectral windows

- **Baseband Name**: Set automatically, one of BB_1, BB_2, BB_3 or BB_4.

- **Desired Centre Frequency**: The desired centre frequency (in sky units) for this BBC. Not needed for the Correlator Config, rather this is maintained as the users desire for the location of this BBC, and thus to calculate the LOs.

- **Actual Centre Frequency (Rest)**: The actual centre frequency (in rest units) for this BBC.

- **Actual Centre Frequency (Sky)**: The actual centre frequency (in sky units) for this BBC.

- **Products**: Allows the user to select both auto and cross correlation products or auto only or cross only. When the accumulation mode is ALMA_FAST, only the auto products are available. The default is CROSS_AND_AUTO.

- **Use 12 GHz filter**: Use the 12 GHz option.

- **Use USB**: Use the USB option.

- **LO2 Frequency Switching**: Check if frequency switching is to be performed at LO2. This will always be false unless FREQUENCY_SWITCHING is selected at the SpectralSpec level.

- **Number of Positions**: The number of switching positions in the switching setup, 1 (which is no switching), 2, 3,or 4.

- **Dwell Time**: Part of the setup for the "switching" definition. The dwell time is the data collecting duration at a given position. dwell time + dead time must be a multiple of 48 msecs. Dwell time is ignored if there is no switching (TBC).

Figure 6.19: The *Spectral Window forms* to provide the Spectral Windows specifications.

6.5.6.3 Spectral Window Tabs

A Spectral Window summary table is visible above the spectral window specification tabs. Apart from a few fields the table also shows the data rates and the sky frequency that can be expected for each spectral window.

- **SpectralWindow Name**: A locally unique name for this spectral window, Automatically set.

- **Centre Offset Frequency**: The centre frequency of the spectral window, between 2000 and 4000 MHz. This value is an offset into the 2GHz bandwidth of the baseband. Can only take discrete values, determined by the step size of the band, i.e. $2\text{GHz}/8192 = 244.141$ kHz.

- **Centre Freq(Rest) LSB/USB**: The centre rest frequency for the LSB and USB.

- **Centre Freq(Sky LSB/USB**: The centre sky frequency for the LSB and USB.

- **Use LSB - Use USB**: Check when using LSB, USB, DSB or NOSB. Note that if this spectral window is LSB, then its frequency (or channel) order is reversed from the sky frequency, i.e., lowest sky frequency is highest baseband frequency. The sideBand mode should be common to all spectral windows in a baseband for SSB receivers.

- **Nominal BW # Channels**: The nominal bandwidth and number of channels of the spectral window.

- **Effective BW # Channels**: The effective bandwidth of the spectral window and the effective number of channels in the spectral window. The effective number of channels is same as the nominal one for ACA correlator, and by 1/16 less than the nominal one for BL correlator.

- **Resolution**: The spectral resolution.

- **CorrConfigMode/Filtermode**: Correlator configuration internal mode number and filter type.

- **Polarization Products**: Options: XX, YY (single pol'n) or XX,YY, (dual pol'n) or XX, YY, XY, YX (full pol'n). The ACA correlator always outputs all 4 polarization products. The ACA correlator will share the setup if it is common to all spectral windows in a baseband. For the ACA correlator, the polarization products can not be changed by the spectral windows.

- **Averaging Factor**: Specifies the number of spectral channels to average together for each subband. This factor is the number of adjacent channels to average together and must be a power of 2, e.g., 1, 2, 4, 8, etc. The spectral averaging factor can be used to reduce the amount of spectral data sent to the Archive.

- **Window Smoothing Function**: An enumerated value representing the data smoothing function to use. One of: UNIFORM, HANNING, HAMMING, BARTLETT, BLACKMANN, BLACKMANN_HARRIS, WELCH.

The following *BL Only* subpanel applies to the Baseline Correlator Setup only:

- **Correlation Bits**: The correlation bits settings for the baseline correlator. Options are: 2x2, 3x3, 4x4. Higher numbers will increase the sensitivity but requires more resources.

- **Oversampling**: Nyquist sampling/oversampling. True means do Nyquist oversampling, False means non-oversampling.

- **Quantization Correction**: Boolean selection to perform quantization ('VanVleck') correction on the lag data. Normally this is true, but for diagnostic purposes, we may wish to view the uncorrected lags. The ACA correlator does not use this parameter, because the ACA-CDP always does the quantization correction on the spectral results.

On the right side the Spectral Average Region table is visible that can be used to specify the spectral bands that are to be averaged. The user can select up to 10 sets of contiguous channels (a ChannelAverageRegion) which contribute to the channel average result. Note that these parameters are based on effective channels. That is, Start Channel must be a zero based index within the effective range of spectral channels and the number of channels is interpreted based on the spectral resolution (band-width per channel) before any spectral averaging (spectralAveragingFactor) has been applied.

- **Start Channel**: Starting (0-based) channel used to calculate the spectral channel average for a given region. This should be an unsigned type.

- **Num. Channels**: Number of spectral channels used to calculate the spectral channel average for the region. This should be a positive integer.

6.5.7 Observing Parameters

The Observing Parameters node provides the intent of the observations More than one may be associated with a single target. There are *Science Parameters* which provide scientific intent of a target and several types of *Calibration Parameters*, providing a calibration intent. A number of calibration parameters sets (e.g. for Holography and Radiometric and Optical Pointing) are intended to provide the intent for a *Scheduling Block*, instead of a target.

Selecting the Observing Parameters node given the overview table of all Observing Parameter types that have been defined. Below follows the descriptions for the fields in the various tabs.

6.5.7.1 Science Parameters

The Science Parameters have the following items:

- **Science Parameters name**: A user settable name, to be used as a mnemonic.

- **Representative Bandwidth**: This is the representative bandwidth for this Science Goal, Note that the sensitivity is a function of bandwidth.

- **Representative Frequency**: This is the representative frequency to use. Note that the sensitivity is a function of frequency.

- **Sensitivity Goal**: The rms sensitivity in Jy or mJy desired for the target when observed at the Representative Frequency with the Representative Bandwidth. This allows specification for either continuum or spectral line observations. It is possible to keep track in near-real-time of the sensitivity already reached. The estimate can improve on that supplied by the OT's ETC because it can access the actual system temperatures.

- **Integration Time on source**: Desired integration time for this source in this SB.

Figure 6.20: The *Observing Parameters* form to provide the parameters for the targets in the SB. The Science parameters tab is visible.

- **Sub Scan Duration**: The subscan duration must be a multiple of the integration duration. This is the number of seconds the subscan will last. When this duration ends, data stops flowing from the CDP.

- **Adjust subscan duration to a correct value**: Ensure that the subscan duration is a multiple of the integration duration.

6.5.7.2   Calibration Parameters

The various calibration parameters tabs share the following items:

- **Calibration Type Parameters name**: A user settable name, to be used as a mnemonic.

- **Cycle Time**: How often this calibrator should be observed within the observing script of the SB (may be overridden when observing).

- **Default IntegrationTime**:A Default integration time on this calibrator (may be overridden when observing)

- **Data Origin**: Data source to use when analysing results from this calibrator target when observed at the Representative Frequency with the Representative Bandwidth Source can be channel, average, cross of auto correlation, wvr, etc.

- **Sub Scan Duration**: The subscan duration must be a multiple of the integration duration. This is the number of seconds the subscan will last. When this duration ends, data stops flowing from the CDP.

- **Adjust subscan duration to a correct value**: Ensure that the subscan duration is a multiple of the integration duration.

The Pointing Calibration Parameter tab has the following additional items:

- **Desired Accuracy**: The desired calibrated accuracy resulting from this calibration

- **Pointing Method**: Method to be used for the calibration

- **Maximum Elapsed Time**: Maximum time allowed to achieve this accuracy.

- **Excursion**: Maximum outwards excursion during the calibration.

The Focus Calibration tab has the following additional item:

- **Axis to adjust**: Specify the axis to focus, i.e. the X, Y or Z axis.

The Atmospheric Calibration tab has the following additional item:

- **Use Hot Load**: Specify whether or not to use the hot load.

- **Coord Type**: Specify the type of the coordinates for the sky position.

- **Sky Position**: Specify the sky position and coordinate system.

The Bandpass Calibration Parameter tab has the following additional item:

- **Desired Amplitude Accuracy**: The desired amplitude accuracy in percent.

The Optical Pointing Parameters has the following items:

- **Antenna Position Tolerance**: The acceptable position tolerance needed before observing.

- **Elevation Limit**: The elevation limit below which not to observe

- **Max Magnitude**: The max magnitude target to observe

- **Min Magnitude**: The Min. magnitude target to observe

- **Randomize Order**: Whether or not to randomize the order of observing the stars

The Holography Parameters has the following items:

- **Frequency**: Frequency to observe at

- **Start Fraction**: How far into the scan to begin?

- **Speed**: Speed to scan at

- **Calibration Rows**: Number of observation rows between periods spent acquiring signal calibration data

- **Calibration Time**: Time spent on each calibration observation

- **Number of Rows**: Number of rows in the scan

- **Row Size**: Size of each row

- **Tower**: name to tower to use

- **Scan Direction**: Which direction to scan in

- **Calibration Mode**: Mode to use

- **uniDirectionalScan**: Whether or not to always scan the same direction

Chapter 7

The Visual Editors

7.1   The Visual Spatial Editor

The Visual Spatial Editor is a graphical tool to aid in choosing input parameters for the Field Setup of a Science Goal or the Field Source of a Scheduling Block. It consists of a graphical interface that is described here, but also contains the Forms editors that are described in Sections 5.2 and 6.5.1. An example of the image display can be seen in Figure 7.1.
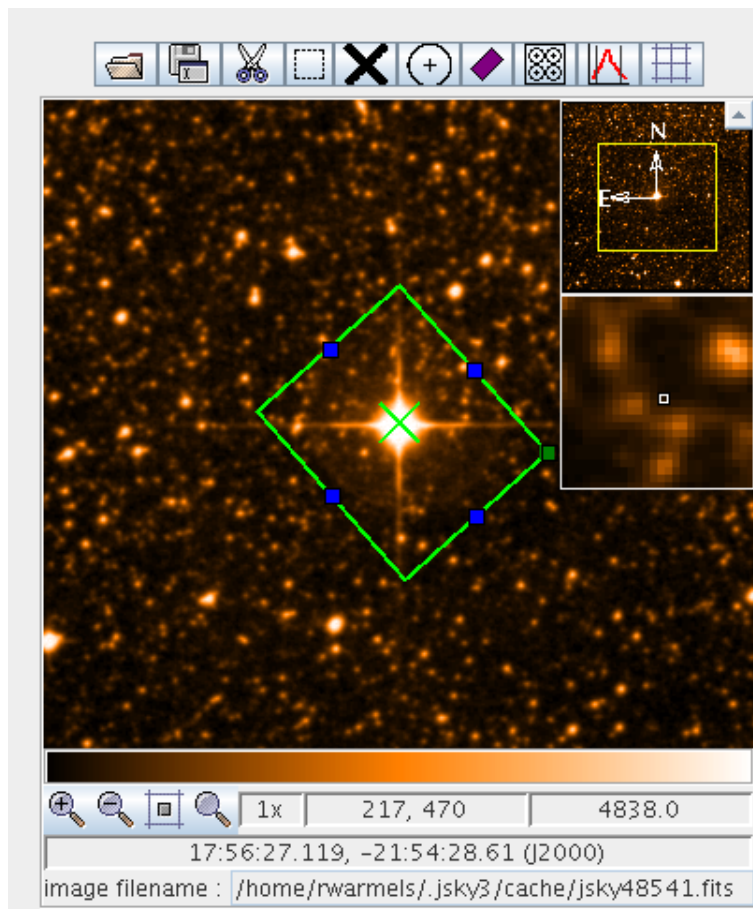

Figure 7.1: An example of the image display area of the Visual Spatial Editor. The source and pointing positions are marked.

7.1.1 Tool Bar and Zooming Functions

A toolbar is visible above the graphical interface. It provides the following functions:

- **Open a FITS file**: Load a FITS file on the display. Note that only the J2000 coordinate system is currently properly supported.

- **Save image as ...**: Save the displayed image. The format can be selected in a separate window.

- **Cut selected FOVs**: Remove a telescope pointing position.

- **Select FOVs in a rectangular region**: Use the cursor to select a number of pointings.

- **Set the target centre (Source Coordinates)**: Mark the centre of the target.

- **Add a FOV**: Add a telescope pointing to the display.

- **Draw a rectangular map**: Use the cursor to define a rectangular region to be mapped. Via the colour anchors the region and be reshaped and rotated. This region can be automatically turned into a mosaic. A larger turquoise rectangle represents the area that will be observed using the ACA TP array (if selected).

- **Show Pointing Positions**: Show the automatically derived mosaic positions for a rectangle field.

- **Image Cut levels**: Set the image cut level and pixel value distribution using a separate interface.

- **Show/Hide Grid**: Display a coordinate grid (RA and Dec).

At the bottom of the display, four buttons are available for zooming functions. In addition the zoom factor, the pixel and sky coordinates at the cursor position and pixel value are visible. The image file name that is loaded is also displayed.
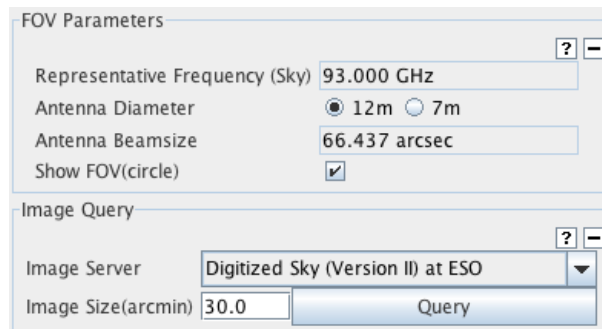
7.1.2 Fov Parameters

Figure 7.2: The antenna beamsize and server query controls of the Visual Spatial Editor.

Below the graphical window are two panels that control the loading of images and various display options.

- **Representative Frequency (sky)**: The sky equivalent of the Representative Frequency is used to determine the antenna beamsize.

- **Antenna Diameter**: Antenna diameter that shall be used for calculation the antenna beamsize. Choices are 12- (12-m and TP arrays) and 7 m (7-m array).

- **Antenna Beamsize**: Diameter of the chosen antenna beam.

- **Show FOV (circle)**: Tick to display the chosen antenna beam.

7.1.3 Image Query

- **Image Server**: Select the image server from which the image shall be retrieved.

- **Image Size (arcmin)**: Set the size of the image to be uploaded. Larger images take more time.

- **Query**: Retrieve and upload the image from the server.

7.2 The Visual Spectral Editor

The purpose of the Spectral Editor is, apart from the graphical presentation of the various parameters settings, to offer the possibility of adjusting and optimising various frequency setting parameters interactively using the cursor. The defined spectral windows are shown along with the tuning solution derived from them. This consists of the receiver sidebands (the spectral windows must all fit inside these) and the first local oscillator frequency (LO1). If a tuning solution has been found, the sidebands will be coloured yellow and, if shifted by dragging LO1 with the cursor, will spring back to their original position once the mouse button is released. If a tuning solution cannot be found, the sidebands turn grey. A project cannot be submitted unless a tuning solution has been found by the OT. A table at the bottom contains all sources that are specified in the Field Setup. Selecting these will move the spectral windows in the graphical interface, but note that the sidebands and LO1 frequency will not shift – these remain at the position appropriate for the first source.

7.2.1 Visual Spectral Editor for Science Goals

The Visual Spectral Editor for Science Goals is divided into five panels. The first section is described below. The other four panels are described in Section 5.3.1.
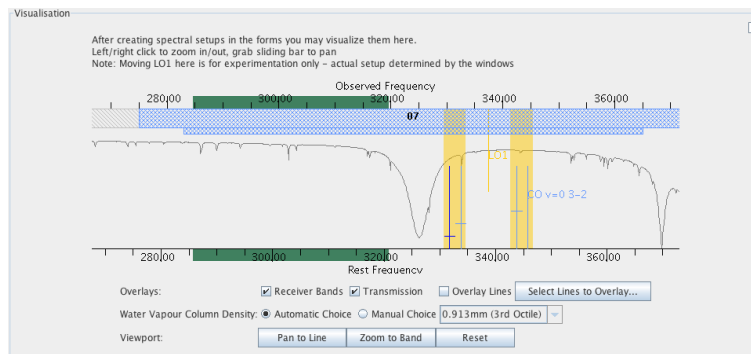

Figure 7.3: The graphical representation of the frequency information for Science Goals.

7.2.1.1 Visualisation

- **Overlays**

  - **Receiver Bands**: Displays the available receiver bands as a hatched bar along the top of the display.
  - **Transmission**: Display the atmospheric transmission curve. This will change depending on what is selected for the Water Vapour Column Density.
  - **Overlay Lines**: Display lines selected with the Spectral Line Selection tool.
  - **Select Lines to Overlay**: Choose lines to overlay using the Spectral Line Selection tool.
  - **Water Vapour Column Density**: Select a value of precipitable water vapour to use for the transmission plot. This can be selected by the OT automatically based on the Representative Frequency (sky value) or can be chosen explicitly. Note that the latter is only for experimentation purposes – the OT's time estimates will always use the automatically-chosen value.
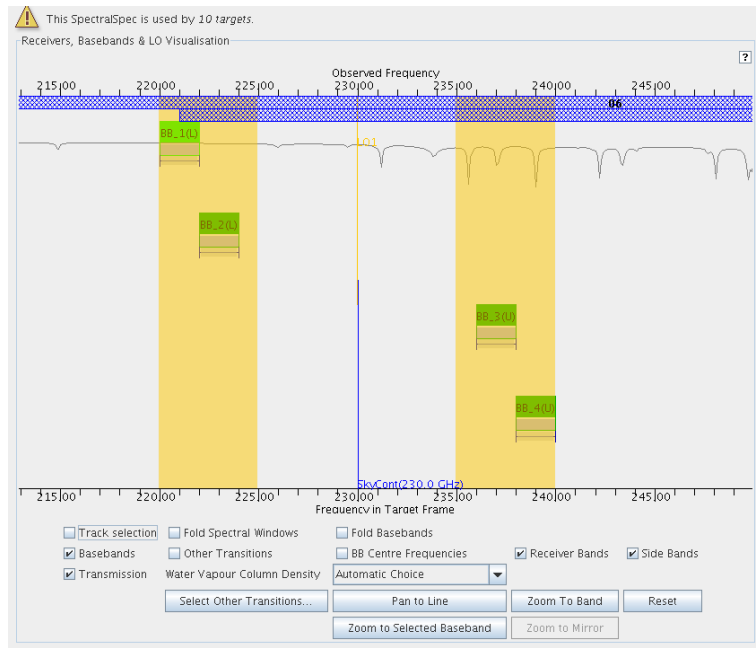
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Figure 7.4: Visualisation of frequency information about receivers, basebands and LO frequencies. Visible are part of the frequency band (hashed), the transmission curve, four basebands and their spectral windows.

- **Viewport**

  - **Pan To Line**: Pan to the rest frequency.
  - **Zoom To Band**: Zoom to the current receiver band.
  - **Reset**: Reset the display settings.

7.2.2   Visual Spectral Editor for Scheduling Blocks

The Visual Spectral Editor is similar to that used in Science Goals, but there are some differences. As with the Science Goal version, a graphical interface is displayed along with the Forms editor – this is described in Section 6.5.3.

7.2.2.1   Receiver, Basebands & LO Visualisation

- **Track Selection**: Control whether or not to zoom to a newly selected baseband.

- **Fold Spectral Windows**: Optimize the use of the vertical space for drawing the spectral windows.

- **Fold Basebands**: Optimize the use of the vertical space for drawing the basebands.

- **Basebands**: Display the baseband ranges.

- **Other Transitions**: Toggle drawing of the other transitions that have been selected.

- **BBC Centre Frequencies**: Display the centre frequencies of the baseband configurations.

- **Receiver Bands**: Displays the available receiver bands 1 to 10.

- **Side Bands**: Display the LSB and USB ranges.

- **Transmission**: Display the atmospheric transmission curve.

- **Select Other Transitions**: Click to start up the Spectral Lines Selecting Tool to select lines to be displayed.

- **Pan To Line**: Pan to the rest frequency.

- **Zoom To Band**: Zoom to the current receiver band.

- **Reset**: Reset the display settings.

- **Zoom to Selected Baseband**: Zoom to the selected baseband.

- **Zoom to Mirror**: Zoom to the mirror (in the LO1 frequency) of the current window.

Chapter 8

Acronym List

ACA: Atacama Compact Array
ALMA: Atacama Large Millimeter/submillimeter Array
ARC: ALMA Regional Centre
ASC: ALMA Sensitivity Calculator
BBC: BaseBand Configuration
DFS: Data Flow System
OT: Observing Tool
DFS: Data Flow Systems
FOV: Field Of View
HLA: High Level Analysis
GUI: Graphical User Interface
ID: Identifier
IPT: Integrated Product Team
JDK: Java Development Kit
JRE: Java Runtime Environment
JVM: Java Virtual Machine
LO: Local Oscillator
LSB: Lower Side Band
OT: Observing Tool
OTF: On The Fly (mapping)
OUS: Observation Units Set
PI: Principal Investigator
SB: Scheduling Block
SSR: Science Software Requirements
TFB: Tunable Filter Bank
USB: Upper Side Band
XML: Extensible Markup Language

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.