Doc. 12.6, Ver. 1.0 | February 2025

ALMA Observing Tool Reference Manual

Anna Miotello, Katharina Immer, Andy Biggs, Rein H. Warmels

www.almascience.org

ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSTC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile.
The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.

User Support:

For further information or to comment on this document, please contact your regional Helpdesk through the ALMA User Portal at **www.almascience.org** . Helpdesk tickets will be directed to the appropriate ALMA Regional Centre at ESO, NAOJ or NRAO.

Revision History:

Version	Date	Editors
0.6, Ver. 1.0	March 2011	Rein Warmels
0.6, Ver. 1.1	August 2011	Rein Warmels
1.6, Ver. 1.0	May 2012	Rein Warmels
1.6, Ver. 1.2	November 2012	Andy Biggs
1.6, Ver. 1.3	February 2013	Andy Biggs
2.6, Ver. 1.0	October 2013	Andy Biggs
3.6, Ver. 1.0	March 2015	Andy Biggs
4.6, Ver. 1.0	March 2016	Andy Biggs
4.6, Ver. 2.0	May 2016	Andy Biggs
5.6, Ver. 1.0	March 2017	Andy Biggs
5.6, Ver. 2.0	June 2017	Andy Biggs
6.6, Ver. 1.0	March 2018	Andy Biggs
6.6, Ver. 2.0	July 2018	Andy Biggs
7.6, Ver. 1.0	February 2019	Andy Biggs
7.6, Ver. 2.0	June 2019	Andy Biggs
7.6, Ver. 2.1	July 2019	Andy Biggs
8.6, Ver. 1.0	January 2020	Andy Biggs
8.6, Ver. 1.1	March 2020	Andy Biggs
8.6, Ver. 1.2	March 2021	Andy Biggs
9.6, Ver. 1.0	March 2022	Andy Biggs
10.6, Ver. 1.0	March 2023	Anna Miotello
10.7, Ver. 1.0	September 2023	Anna Miotello
11.6, Ver. 1.0	March 2024	Katharina Immer
12.6, Ver. 1.0	February 2025	Anna Miotello

Contributors

The ALMA OT Team and the many testers.

In publications, please refer to this document as:
ALMA Observing Tool Reference Manual, ALMA Doc. 12.6, Version 1.0

Contents

1 Introduction **5**
1.1 How to Use this Manual . . . 5
1.2 Release Information . . . 5
1.3 Credits and Acknowledgements . . . 5

2 Overview of the Observing Tool **7**
2.1 Menu Bar . . . 7
2.1.1 File . . . 7
2.1.2 Edit . . . 9
2.1.3 View . . . 9
2.1.4 Tools . . . 10
2.1.5 Search . . . 10
2.1.6 Debug . . . 10
2.1.7 Help . . . 10
2.2 Tool Bar . . . 11
2.3 Panes . . . 11
2.3.1 Project Structure . . . 11
2.3.1.1 Proposal . . . 11
2.3.1.2 Program . . . 11
2.3.1.3 Template Library . . . 12
2.3.2 Editors . . . 12
2.3.3 Feedback . . . 13
2.3.4 Overview . . . 13

3 Tools and Simulators **15**
3.1 Calibrator Selection Tool . . . 15
3.2 Spectral Line Picker . . . 15
3.3 ALMA Sensitivity Calculator . . . 16
3.3.1 Common Parameters . . . 16
3.3.2 Individual Parameters . . . 17
3.3.3 Buttons . . . 17
3.4 LO Configuration Tool . . . 17
3.4.1 Hardware Info . . . 17
3.4.2 Settings . . . 17
3.4.3 TuningParameters . . . 18

4 The Phase 1 Proposal: Basic Details **19**
4.1 Project Node . . . 19
4.1.1 Principal Investigator . . . 19
4.1.2 Main Project Information . . . 19
4.1.3 Project Notes . . . 19
4.1.4 Advanced Options . . . 20
4.2 Proposal Information . . . 20
4.3 Joint Proposals . . . 21

4.4 Investigators . . . 21
4.5 Reviewer Information . . . 22
4.6 Science Case . . . 22
4.7 Team Expertise . . . 22
4.8 Scheduling Feasibility . . . 23
4.9 Duplicate observations . . . 23
4.10 Observatory Use Only . . . 23

5 Phase 1 and Phase 2 Science Goals **25**
5.1 General . . . 25
5.2 Field Setup . . . 25
5.2.1 Source . . . 26
5.2.2 Expected Source Properties . . . 27
5.2.3 Field Center Coordinates . . . 28
5.2.4 Rectangle . . . 29
5.2.5 TP Regional Mapping . . . 30
5.3 Spectral Setup . . . 30
5.3.1 Spectral Type . . . 30
5.3.2 Spectral Setup Errors . . . 30
5.3.3 Spectral Line . . . 31
5.3.4 Single Continuum . . . 32
5.3.5 Spectral Scan . . . 33
5.3.6 Rest Frequencies . . . 34
5.3.7 Targets . . . 34
5.4 Calibration Setup . . . 34
5.4.1 Goal Calibrators . . . 34
5.4.2 Astrometry . . . 35
5.4.3 DGC Override . . . 35
5.5 Control and Performance . . . 35
5.5.1 Configuration Information . . . 35
5.5.2 Desired Performance . . . 36
5.6 Technical Justification . . . 37
5.6.1 Sensitivity . . . 38
5.6.2 Imaging . . . 38
5.6.3 Correlator configuration . . . 38
5.6.4 Choices to be justified . . . 39

6 Phase 2 Program Scheduling Blocks **41**
6.1 Observing Unit Set . . . 41
6.1.1 Basics . . . 41
6.1.2 Control . . . 41
6.2 The Scheduling Block . . . 42
6.2.1 Basics . . . 42
6.2.2 Control . . . 42
6.2.3 Unit Dependencies . . . 43
6.2.4 Preconditions . . . 43
6.2.5 SchedBlock . . . 43
6.2.6 Advanced Parameters . . . 44
6.2.7 Performance Goals and Scheduling Constraints . . . 44
6.2.8 Temporal Constraints . . . 45
6.2.9 Observing Groups . . . 45
6.3 Observing Groups . . . 45
6.4 Targets . . . 45
6.5 Field Sources . . . 45
6.5.1 Query Status . . . 45
6.5.2 Field Source . . . 45

6.5.3 Reference Position (Offset) . . . 46
6.5.4 FieldPatternEditor . . . 47
6.5.4.1 Point . . . 47
6.5.4.2 Fill . . . 47
6.5.4.3 Rectangle . . . 48
6.5.4.4 Cross . . . 49
6.6 Instrument Setup . . . 49
6.6.1 Spectral Spec . . . 49
6.6.2 Switching . . . 50
6.6.3 Correlator Configuration . . . 50
6.6.4 BaseBand Configurations . . . 51
6.6.4.1 Hardware Setup . . . 51
6.6.4.2 LO Setup Preference . . . 51
6.6.4.3 Basebands . . . 52
6.6.4.4 Spectral Windows . . . 53
6.7 Observing Parameters . . . 55
6.7.1 Science Parameters . . . 55
6.7.2 Calibration Parameters . . . 56
6.7.2.1 Common Parameters . . . 56
6.7.2.2 Phase-only Parameters . . . 57
6.7.2.3 Bandpass-only Parameters . . . 57
6.7.2.4 Pointing-only Parameters . . . 57
6.7.2.5 Focus-only Parameters . . . 57
6.7.2.6 Polarization-only Parameters . . . 57
6.7.2.7 Atmospheric-only Parameters . . . 57
6.7.2.8 Optical Pointing-only parameters . . . 58
6.7.2.9 Radiometric Pointing-only parameters . . . 58
6.7.2.10 Holography-only Parameters . . . 58

7 The Visual Editors **59**
7.1 The Visual Spatial Editor . . . 59
7.1.1 Tool Bar and Zooming Functions . . . 59
7.1.2 Fov Parameters . . . 60
7.1.3 Image Query . . . 61
7.2 The Visual Spectral Editor . . . 61
7.2.1 Visual Spectral Editor for Science Goals . . . 61
7.2.1.1 Visualisation . . . 61
7.2.2 Visual Spectral Editor for Scheduling Blocks . . . 62
7.2.2.1 Receiver, Basebands & LO Visualisation . . . 62

8 Acronym List **65**

This page was intentionally left almost blank

Chapter 1

Introduction

The OT Reference Manual provides a concise description of the inputs to the ALMA Observing Tool (OT) that is used to prepare observing proposals (Phase 1) and to schedule approved observations (Phase 2) for the Atacama Large Millimeter/submillimeter Array (ALMA). The OT is a Java-based application consisting of a set of user interfaces that are needed to prepare an ALMA observing project. This consists of a valid observing proposal and/or an observing program containing one or more Scheduling Blocks that are executed at the telescope.

1.1 How to Use this Manual

For most users preparing to submit a proposal to ALMA or who are preparing SBs for observation, the User Manual gives the fullest description of how the OT actually works. However, this does not go into detail of what every button in the OT does and what the meaning of every parameter is. When this kind of information is required, the OT tooltips (revealed by hovering the mouse over an input field) will often help. However, these are by their very nature very concise and thus the OT Reference Manual is provided as a source of detailed information on each parameter.

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 Chapter 7.

1.2 Release Information

This version of the manual is intended to be used with the OT that will be used to submit normal (non-DDT) proposals for Cycle 12.

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.

This page was intentionally left almost blank

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.

2.1 Menu Bar

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

2.1.1 File

The File menu contains entries 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 proposal for the Main Call submission deadline and scientific and technical review process. This will require proposal details and Science Goals to be added.
- **New DDT Proposal**: Create a proposal for submission under the auspices of Director's Discretionary Time. This has no fixed deadline and can be submitted at any point during the observing period of the current cycle. The project codes of DDT proposals are differentiated from normal proposals in that they use a letter to denote the sub-cycle e.g. `2019.A.00001.S`.
- **New Supplemental Call Proposal**: Create a proposal for submission to the ACA Supplemental Call. The project codes of Supplemental Call proposals are differentiated from normal proposals in that they use a different number for the sub-cycle e.g. `2019.2.00001.S`. This option will only be available in the OT configured for the Supplemental Call.
- **New Program**: Create a new Phase 2 program using Science Goals or Scheduling Blocks. Only available to privileged users.
- **New Commissioning Program**: Create a new Phase 2 program if you are working on commissioning in Chile. Such projects follow a different life cycle than a standard PI-submitted one i.e. after submission they enter the state `CSVReady` and not `Phase2Submitted`. Life cycles can be viewed using the Project Tracker. This option is only available to privileged users and is synonymous with selecting "Commissioning Mode" from the Advanced Options panel. Commissioning Programs get the `CSV` project-code suffix upon submission. Note that it makes most sense to create commissioning programs when the OT is running in its CSV mode as this enforces different validation rules that are more appropriate for testing. This is most easily started using the tarball OT by changing the `-DTelescope` option of the `ALMA-OT.sh` script to `ALMACSV`.

- **New VLBI Program**: This will create a new Phase 2 program and any Science Goals added to this will be in VLBI format. If it is desired to copy a Science Goal from a Phase 1 proposal into a new Phase 2 program, this option must be used. Only available to privileged users.

- **New Supplemental Program**: This will create a new Phase 2 program for a Supplemental Call project.

- **Open Project**: Open a project from the local disk or the ALMA Archive. There is also a project-finding tool, but this is of limited value and may not even work anymore.

- **Open Archive Project as New Proposal**: The main purpose of this is to allow a project that is stored in the archive and is in a Phase 2 state (probably containing SBs) to be "recycled" as a new proposal, but it will also convert a Phase 1 archived project (even a rejected one) into a new proposal. The new proposal will contain all the previous Phase 1 information (including Science Goals) whilst the Phase 2 information is removed. Even if the proposal being opened was DDT, it will be opened as a non-DDT proposal.

- **Open Archive Project as New DDT Proposal**: This is similar to the previous option, but the project will be converted to a DDT proposal.

- **Open Archive Project as New ACA Supplemental Call Proposal**: This is similar to the two previous options, but will open the project as a new ACA Supplemental Call proposal. For normal users, this will only be possible in the version of the OT configured for this purpose. It will not allow this if the project is for VLBI or solar observing.

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

- **Save As**: Save a project to the local disk as a new file. The filename prefix must contain at least 3 characters.

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

- **Use Project as Template**: Open an ALMA project (either from the local disk or the archive) and show it in read-only mode. Project entities (such as Science Goals) can be copied (dragged and dropped) from the template to the active project. If the active project is in Phase 2 and the template is in Phase 1, it will be necessary to change the displayed phase using the tabs at the top of the Project Tree ('Proposal' and 'Program'). This will not work in the opposite case i.e. active project in Phase 1 and template in Phase 2 - the Phase 2 contents of the template will not be reachable.

- **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 Project 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. This action does not change the phase of the project e.g. a Phase 2 project will remain in Phase 2. Only available to privileged users.

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

- **Save Preferences**: Save the preferences of the current session to disk. Whether this will prove useful is yet to be seen. What the OT does do is compare the current preferences to those saved at the end of a session and, if they'e changed, ask if you wish to overwrite them. This is really only useful for developers who are running multiple versions of the OT.

- **Quit**: Shut the OT down.

2.1.2 Edit

The Edit menu is used for project editing functions (cut, paste, delete, rename) and for adding/deleting project components like Science Goals of SB parameters. On Linux, the modifier key is Ctrl, whilst on a Mac it is the Command key. On both systems, Ctrl-A will highlight all the text contained within a text field.

- **Cut**: Cut highlighted text from a text field.
- **Copy**: Copy some highlighted text or an item from the Project Tree (the latter will turn pink).
- **Paste**: Paste copied text into a text field, or a Project Tree item into a folder e.g. a copied Phase 1 Science Goal into the Planned Observing folder.
- **Rename**: Rename various Project tree items.
- **New Science Goal**: Create a new Science Goal.
- **Clone node**: This allows a user to quickly clone (copy and paste in a single action) parts of the Project Tree. The nodes that can be cloned are Science Goals, ObsUnitSets, Scheduling Blocks, Targets or any of the SB Resources i.e. Field Sources, Instrument Setups or Observing Parameters. This option is also available when right clicking on these nodes. If a SG is cloned that contains ObsUnitSets and below, these are not cloned. It is not possible to clone the top-level Science Goal OUS or individual parts of a SG.
- **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. There is no undo action.
- **Suspend**: Suspend the observation of this Scheduling Block. Not used.
- **Resume**: Allow further observation of the Scheduling Block. Not used.
- **Mark as Repaired**: Mark the Scheduling Block as repaired. Not used.
- **Terminate**: Terminate the observation of the Scheduling Block. Not used.

2.1.3 View

- **Feedback**: Display or hide the Feedback panel. If hidden, it will be re-displayed the next time a project is validated.
- **Overview**: Display or hide the Overview panel. This is only really useful for beginners.
- **Expand all**: Display all parts of the Project Tree below the selected branch.
- **Find previous**: Move to the previous occurrence of the selected branch of the Project Tree. For example, if the Spectral Setup of the last Science Goal has been selected, this button (or its related shortcut) will jump to the Spectral Setup of the previous SG.
- **Find next**: As above, but moving to the next occurrence of the selected branch of the Project Tree.
- **Show ALMA Template Library**: Show the ALMA Template Library in the Project Structure tree. Disabled.

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.
- **Sensitivity Calculator...**: Start up the ALMA Sensitivity Calculator. The inputs are independent of those entered into the main OT GUI, but will be remembered if the calculator is shut and subsequently re-opened.
- **Generate SBs from the Selected Goal**: Create one or more SBs from the selected Phase 1 or Phase 2 Science Goal.
- **Display Project Time Summary**: This brings up a dialogue that contains the time required for each Science Goal. This is broken down into the different arrays and time spent calibrating, where this can be calculated. It also includes data-volume and -rate information.
- **Generate Phase 1 SBs from all the Science Goals**: Create one or more SBs from all of the Phase 1 Science Goals. This option is only available if the Proposal node has been clicked and if the user has enabled privileged operations.
- **Generate Phase 2 SBs from all the Science Goals**: Create one or more SBs from all of the Phase 2 Science Goals. This option is only available if the Science Plan folder has been clicked.
- **Export selected SchedBlock to File**: Privileged users can export a single SB to disk by highlighting it in the Project Tree and selecting this option. The file extension "xml" will be enforced.
- **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 whole proposal or of all or individual Science Goals.
- **Generate a PDF for the Whole Proposal**: This PDF contains the cover sheet, Science Goal summary sheets (including technical justification information) and the scientific justification.
- **Disable Edit Protect**: If OUS Write Protection has been enabled in the Preferences menu (available to privileged users only) it can be disabled here.

2.1.5 Search

If warnings or errors have been found during the validation process it is possible to double-click on them to be taken to the location in the Project Tree that is causing the problem. Alternatively, one can scroll through them using the following menu items.

- **Go to previous Problem**:
- **Go to next problem**:

2.1.6 Debug

This menu item is only displayed when activated via the Preferences menu and is only available for privileged users i.e. developers.

2.1.7 Help

Various sources of information can be displayed in a searchable and indexed GUI.

- **User Manual**: This provides detailed descriptions of how the OT is used in practice.

- **Reference Manual**: This document.
- **About...**: Bring up a dialogue that reveals various information about the OT.
- **Release Notes...**: This jumps to the "Release Notes" section of the "About..." menu. It contains information on new features, improvements and bug fixes.

2.2 Tool Bar

The toolbar contains buttons for executing frequently used OT functions and tools that are otherwise available from the various menu items. Note that the availability of the tools and functions depends on which phase of project is being worked on and the user's permissions.

The only function that is not available elsewhere is the contextual help icon (question mark) which displays help (from this Manual) depending on which section/panel of the OT is clicked.

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.
- **Technical Justification**: This node allows a user to justify various technical aspects of the Science Goal and displays a lot of information in order to guide this.

2.3.1.2 Program

Using the Program tab, Phase 2 details are usually added by defining a Science Goal (basically identical to that found in the Proposal tab) and then generating Scheduling Blocks automatically from this. It is also possible to build the SB manually, but this is not recommended. SBs contain all necessary information to execute an observation and consist of:

- **Resources**: These are the building blocks of an SB and detail various aspects of the observations:

  - **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.

- **Targets**: Each of these consists of a Field Source, an Instrument Setup and an Observing Parameters.

- **Observing Groups**: Each Target must be placed into an Observing Group or else it will not be observed. Amplitude and bandpass calibration are usually only carried out in the first Observing Group.

In addition, Scheduling Blocks must be placed into Observing Units Sets, or OUSs. There must always be three levels of OUS under the Science Plan folder:

- **Member OUS**: SBs are stored in the MOUS folder. Each MOUS currently corresponds to a different array configuration i.e. 12-m, 7-m and TP Array. It is only possible to store a single SB per MOUS, except for commissioning programs for which there is no restriction.

- **Group OUS**: This folder can contain multiple MOUSs, the SBs of which will be combined together during data processing. Multiple GOUSs are possible, each of which corresponds to an observation that is separate i.e. data from different GOUSs will not be combined. For example, each visit of a multiple-visit, time-constrained observation is contained within a separate GOUS.

- **Science Goal OUS**: There is only one of these per Science Goals and contains all the Group OUSs.

2.3.1.3 Template Library

The lower section of the Project Structure pane can be used to load the ALMA Template Library or to display a local ALMA project in read-only mode. Parts of the templates can be copied (or dragged and dropped) and used for an active project. **The option to load the Template Library is currently disabled.**

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. It is only possible to view this if a spectral or instrument setup has been chosen in the Project Tree (including Targets). The OT will default to showing the spectral visualiser as this should usually be viewed when defining spectral windows. In the SB, the OT will instead remember the last choice.

- **Spatial**: Enable the Visual Spatial Editor to display the science object obtained from one of the image servers available via the network. It is only possible to view this if a field setup or source has been selected in the Project Tree (including Targets). As with the spectral tab, the OT defaults to showing the spatial tab.

- **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 provides error and/or warning messages when running the validator. There are three tabs: Validation, Validation History and Log.

- **Validation**: Shows a table of the error and warning messages, 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.

This page was intentionally left almost blank

Chapter 3

Tools and Simulators

The OT is equipped with a number of tools: the Calibration Selection Tool, the Spectral Line Picker (SLP), the Sensitivity Calculator and the LO Configuration 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 flux 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.

3.2 Spectral Line Picker

The spectral line catalogue used by the OT is the Splatalogue[1] and the millions of spectral line transitions contained within this can be searched for and selected using the Spectral Line Picker. This appears at various

[1] https://splatalogue.online

points in the OT where it fulfils different functions: creating spectral windows, overlaying lines in the Visual Spectral Editor and defining rest frequencies. The OT itself contains a useful subset of the whole Splatalogue, but there is also the option to search the whole Splatalogue on-line.

- **Transition 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.
- **Receiver/Back End Configuration**:
  - **All lines**: Perform no filtering i.e. show all lines.
  - **Potentially selectable lines**: Show lines that might possibly give a valid tuning solution if added to the current setup.
  - **Lines in defined spws**: Only show those lines which fall into the currently defined spectral windows. This is the only option when defining rest frequencies.
- **Upper-state Energy**: This filter sets the minimum and maximum energy levels of the upper state of the transitions.
- **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

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.
- **Observing Band**: This is mainly there for information purposes i.e. to make clear which band is being used. However, where frequency bands overlap (Bands 4 and 5) or join together (e.g. Bands 6 and 7) it is possible to choose which Band should be used in the calculation.
- **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 and corresponding octile (1–7). A number of standard values can be selected, but the tool defaults to automatically determining these based on the observing frequency.
- **Trx, tau, Tsky**: Display of the receiver temperature, zenith opacity and sky temperature (at the target's maximum elevation) given the previous selection.
- **Tsys**: Display of the derived system temperature.

3.3.2 Individual Parameters

- **Number of Antennas**: The number of antennas per array. These default to the expected numbers in the cycle corresponding to the version of the OT.
- **Resolution**: Desired angular resolution. This cannot be entered for the TP Array as this is a fixed number (antenna beamsize).
- **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 (*not* spectral window) frequencies, 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.
- **Receiver Band**: Select the receiver band. This is only necessary when defining basebands that fall into the overlap region between Bands 4 and 5. For example, a baseband at 160 GHz will default to Band 4, but can be forced to Band 5 using this menu.
- **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).

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.

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.

4.1 Project Node

The Project node is common to both Phase 1 and 2 and contains a number of different panels.

4.1.1 Principal Investigator

This panel allows the PI to be defined in exactly the same way as in Proposal Information (Section 4.2).

4.1.2 Main Project Information

This panel contains the following fields:

- **Project**: The title of the project can be entered here and is limited to 120 characters. As with the PI, this information can also be entered in the Proposal Information panel.
- **Assigned Priority**: Not yet used.
- **Project Code**: A unique code for the project, assigned automatically upon its first submission. The format consists of four separate fields:
  - Year of submission (4 digits)
  - Period of submission (single digit or, for DDT proposals, a single character)
  - Order of submission (5 digits)
  - Letter Code (a single character for PI projects - observatory projects can use more characters).

  For example, the first DDT submission of Cycle 7 would have had the code `2019.A.00001.S`, providing it was a Regular proposal.

4.1.3 Project Notes

This panel is only available to privileged users. It shows four text boxes, the first of which will accept new text. The other three show information in read-only format taken from proposal review process.

- **Staff Project Note**: Staff can commumicate issues to each other using this text box.
- **Technical Assessor's Phase 2 Comments**: The outcome of TA will have comments specifically for the person responsible for constructing the SBs.
- **Technical Assessor's Main Comments**: These TA comments are intended for the PI.
- **Consensus Report**: The review panels consensus report is reproduced here.

4.1.4 Advanced Options

This panel can also only be used by privileged users.

- **Version**: This is set by the observatory staff to something that will help them keep track of the various versions of the project.
- **Manual Mode**: Back in the Stone Age it was necessary to submit dummy projects to the archive for the purpose of creating 'manual arrays'. It was only available for a Phase 2 project but is no longer used.
- **Simulation Mode**: The only action of this seems to be to set the final part of the project code to `.SIM`. Pointless?
- **Calibration Mode**: Certain projects are used for observatory calibration and checking this checkbox will set the project code to `.CAL`.
- **Commissioning Mode**: Projects used for commissioning new capabilities should have this checked. The project code will be set to `.CSV`. This is equivalent to opening a New Commissioning Project. Only available in Phase 2.

4.2 Proposal Information

- **Proposal Title**: The title of the project can be entered here and is limited to 120 characters.
- **Proposal Cycle**: This is formed from the proposal year and the submission period. If a non-submitted proposal created during a previous cycle is read into the OT the old proposal cycle will be shown, but this will be updated to the current cycle if the project is then submitted.
- **Abstract**: The abstract can be entered as plain text and is limited to 1200 characters.
- **Proposal Type**: Four projects types are currently available
  - Regular (Letter Code = `S`): This type of project is essentially the opposite of Large i.e. the total time required must be less than the criteria for Large projects.
  - Large (Letter Code = `L`): If >50 hours of 12-m Array or >150 hours of 7-m Stand-alone ACA time is requested, this Proposal Type must be selected. Projects must receive an A grade in order to receive time and are allowed a longer Scientific Justification. This proposal type is not available for ACA Supplemental Call proposals.
  - Target of Opportunity (Letter Code = `T`): These projects will need to be triggered during the observing period. It is not necessary to enter the source coordinates as these may not be known at proposal submission time. This proposal type is not available for ACA Supplemental Call proposals.
  - VLBI (Letter Code = `V`): Selecting this will significantly change the information that must be entered into the Science Goal. A proposal must also be submitted to the other telescopes that will form the VLBI array. This proposal type is not available for ACA Supplemental Call proposals.
  - Phased Array Mode (Letter Code = `P`): This is very similar to the VLBI mode and requests use of the phased-up array that is used for VLBI observations. However, in this mode the ALMA antennas operate as a single instrument and are not combined with data from other telescopes.

  - Once a proposal type has been selected and the proposal submitted, the proposal type cannot be changed anymore. If the proposing team wishes to submit the proposal with a different proposal type, they need to retract the current proposal via a helpdesk ticket and re-open their project as a new proposal where they then can change the proposal type.

- **Scientific Category**: A set of radio buttons for selecting the proposal's science category:
  - Cosmology and the High Redshift Universe
  - Galaxies and Galactic Nuclei
  - ISM, star formation and astrochemistry
  - Circumstellar disks, exoplanets and the solar system
  - Stellar Evolution and the Sun.

- **Keywords**: Assign at least one and preferably two keywords to the project. The second keyword is added by holding down the Shift or Ctrl key in the way that you're probably used to.

4.3 Joint Proposals

This allows the PI to select if this is a Joint Proposal with other facilities. If Joint Proposal is selected then the PI should declare if ALMA is the Main Observatory or a Partner Observvatory.

- **Main**: ALMA is the Main Observatory, meaning it is the observatory where the largest amount of time is requested, either on the 12-m Array, or on the 7-m Array for ACA-only projects. One or more Partner Observatories can be selected among JWST, VLA, and VLT, the project codes can be entered, and the amount of requested time is required. A technical justification of the requested time on each partner observatory is required (more details can be found in the Proposer's Guide).

- **Partner**: ALMA is one of the Partner Observatories, or the only Partner Observatory. The Main Observatory and one or more Partner Observatories can be selected among JWST, VLA, and VLT, the project codes can be entered, and the amount of requested time is required.

4.4 Investigators

This contains information about the proposal investigators. All investigators must already be registered with ALMA via the Science Portal. The PI is required and one or more Co-PIs (Large Programs only) and Co-Investigators (Co-Is) may also be added.

For each investigator the following details are displayed:

- **Type**: Is this a PI, a Co-PI or a Co-I? Co-PIs are only allowed for Large Programs and VLBI proposals and have equal access rights to the data. The time for the proposal is charged to the different Executives in accordance with the number of Co-PIs from each. Investigator names are no longer shown on the Cover Sheet.

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

- **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.

- **Reviewer**: This is the only editable column and is used to designate the investigator who will be responsible for reviewing proposals.

Investigators are entered into the table using the buttons below the panel:

- **Select PI**: Complete the PI data by accessing the ALMA user database.
- **Add CoPI**: Complete the Co-PI data in the same way. This is only available for Large Programs.
- **Add CoI**: Complete the Co-I data in the same way.
- **Remove Collaborator**: Delete a highlighted investigator from the table. If multiple rows are highlighted i.e. using the Shift or Ctrl/Cmd keys (depending on your operating system) these can be deleted simultaneously using a single click. Note that PI's can only be changed, not deleted.
- **Add from Proposal...**: Add the investigators from a previous project as Co-Is.

4.5 Reviewer Information

A reviewer must be nominated to participate in the Distributed Peer Review (DPR) process. The OT will request that reviewer information be added if the proposal is not a Large Proposal. More information can be found in the Proposer's Guide.

Once a reviewer has been selected, it is necessary to enter some additional information about that investigator.

- **Reviewer has a PhD?**: Simply indicate whether this is the case or not. If the PI has been selected as a reviewer and they do not have a PhD, additional entry fields will appear. A Co-I must have a PhD if they are set as the reviewer.
- **Select Mentor**: The PI's mentor can be selected from the list of registered ALMA users using this button.
- **Mentor has a PhD?**: This must be the case and if not there will be a validation error.

4.6 Science Case

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 four pages, or seven for Large Programs. The minimum font size is 12 point and an error will be issued if >15 per cent of the text is smaller than this. Note that cropping a figure from a document can lead to text outside the cropped area still being present in the extracted figure.

The PDF should not contain the technical case as this is instead entered as part of each Science Goal. Figures that might be referred to as part of the technical justification should though be included in the PDF.

The buttons are:

- **Attach**: Launch a file browser dialogue to allow the user to choose the PDF file.
- **Detach**: Remove a previously attached file from the proposal.
- **View**: Ask the desktop operating system to launch a viewer to display the document. *Note:* this relies on the operating system being correctly configured and an appropriate application installed.

4.7 Team Expertise

If the proposal is a Large Program, a document describing team expertise must be attached. This is a PDF file with a maximum of one page and a maximum size of 1 MB. The same font-size restrictions as used for the Science Case PDF apply.

4.8 Scheduling Feasibility

If the proposal is a Large Program, then the proposer group is required to assess the scheduling feasibility of the proposal following the configuration/LST scheduling constraints for Large Programs as described in the Proposer's Guide, and indicate through this check box that they have done this work and that the program complies with the scheduling requirements.

4.9 Duplicate observations

Before a proposal is submitted, the ALMA Science Archive should be checked to see that duplicate observations do not already exist. If they do, it should be explained here why the observations need to be repeated. A single panel is provided for free-format text as well as a clickable link to the ALMA duplication policy.

4.10 Observatory Use Only

This panel is not currently used.

This page was intentionally left almost blank

Chapter 5

Phase 1 and Phase 2 Science Goals

Science Goals are designed to capture the scientific aims of a particular observation whilst hiding the technical details of the observations from the user. The technical information is contained within Scheduling Blocks (Section 6) that are automatically generated from the (Phase 2) Science Goal.

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

5.1 General

This is used to provide the name and description of the Science Goal. Whilst the latter is optional, it is necessary that all SGs in a proposal have unique names. These can also be changed by right-clicking on a Science Goal in the Project Tree.

Also included is a checkbox that indicates whether the SG has been descoped by the proposal review process. Therefore, this can only even be checked in a Phase 2 SG. If it is checked, it will not be possible to generate SBs.

Privileged users can also define Expert Parameters. These work in the same way as those definable in the Scheduling Block and allow the SB generation to be changed from its default behaviour. The prototypical use case is the ability to use a keyword-pair that will cause TP SBs to use the TP Spectrometer during commissioning (this cannot be changed after SB generation). As with the SB parameters, it is foreseen that any Expert Parameter is a temporary measure before the default SB generation is changed to reflect the results from commissioning.

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 individual (one or more) pointings or a single rectangle (that will be automatically mosaiced) can be defined. The OT includes a clustering algorithm that will attempt to split the sources into multiple clusters such that all the pointings lie within 10 degrees of each other (1 degree for long-baseline projects) with a maximum of 150 pointings per cluster. At Phase 2 each cluster is written into a separate Scheduling Block.

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

- **Add Source**: Add a science source, the details of which can either be "resolved" from SIMBAD or NED, or added manually. Source names composed of only numbers are not allowed; in such cases a letter should be added to the source name.
- **Load from File...**: Add one or more sources, including their properties, using a local ASCII file. Source

coordinates can be entered either in sexagesimal (ICRS) or decimal degrees (Galactic). The format of the file (case-insensitive) is as follows:

```
Name, RA|Galactic Long (Degs), Dec|Galactic Lat (Degs), PMRA(mas/yr), PMDec(mas/yr),
vel(km/s), Ref frame, Doppler type, peak cont flux(mJy), peak line flux(mJy), cont pol(%),
line pol(%), line width(km/s), cont circular pol (%), line circular pol (%)
--   This signals end of the header
ngc253, 00:47:33.134, -25:17:19.68, 0.0, 0.0, 258.6, lsrk, RADIO, 200, 1000, 2, 0, 1500, 0, 0
ngc1068, 02:42:40.771, -00:00:47.84, 0.0, 0.0, 1142.0, topo, OPTICAL, 1100.0, 30, 0, 0, 20, 0, 0
```

- **Export to File...**: Write the source positions to a local ASCII file.
- **Clone Source**: Create a copy of the currently selected source.
- **Delete Source**: Delete the currently selected source – only available if there is more than one source.
- **Delete All Sources**: This is also only available if there is more than one source.

5.2.1 Source

- **Source Name**: 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. Spaces are replaced by underscores.
- **Resolve**: Fill in source details by searching for the entered source name in SIMBAD or NED. SIMBAD is checked first and then NED if no match was found. Check the details very carefully! Note that the so-called IAU format e.g. B0218+357, is no longer allowed – an additional identifier (usually of a survey) must be placed before the coordinates e.g. JVAS B0218+357.
- **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. The source coordinates and velocity definitions are not displayed if a solar system object is selected as the system that controls the observations has detailed ephemeris information for each object.
  - **Name of Object**: Recognised objects are:
    - Stars: The Sun. This is a special target as it requires that an ephemeris be entered. This can be generated using the Solar Ephemeris Tool that is located within the Science Portal.
    - Planets: Mercury, Venus, Mars, Jupiter, Saturn, Uranus and Neptune.
    - Satellites: The Moon, Ganymede, Callisto, Io and Titan.
    - Dwarf planets: Pluto and Ceres.
    - Asteroids: Pallas, Juno and Vesta.
    - Ephemeris: Load a JPL HORIZONS format ephemeris[1]. The source name will be extracted from the ephemeris and inserted into the appropriate field.
- **Source Coordinates**: Note that these fields do not appear for solar-system objects.
  - **System**: Only ICRS or Galactic should be chosen. ICRS is effectively the only system that is supported by the telescope control system and all calibrator positions are measured within this frame. This means that even if FK5 were selected, the position will be interpreted as ICRS and the output image will be in this coordinate system. Given that all ALMA observations are implicitly made in the ICRS frame, the OT will simply change an FK5 label to ICRS during SB generation. The coordinates will not be transformed, but this is not a problem as the offset between ICRS and FK5 is so small (tens of mas). Therefore, the source may not appear at the expected location within the image, but the image coordinate axes will be correct. Any offset would in any case only be noticeable for very high angular resolution observations. If Galactic coordinates are entered, these will be properly converted to ICRS as part of SB generation.

[1] http://ssd.jpl.nasa.gov/horizons.cgi

- **Sexagesimal display?**: ICRS (and FK5) coordinates will be displayed in sexagesimal format if this is ticked (default). Unclicking this will allow input in degrees for these systems.
- **RA**: Source Right Ascension. Default input formats are sexagesimal for ICRS (or FK5) and degrees for everything else.
- **DEC**: Source Declination. Ditto.
- **Parallax**: Source parallax. Note that negative values are possible when resolving the source using an external server. This is due to the parallax being small compared to the measurement error.
- **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 ICRS position refers to Epoch J2000.
- **PM DEC**: Proper motion in the declination direction. Units should be milliarcsec/yr.

- **Source Radial Velocity**: Note that these fields do not appear for solar-system objects. The radial velocity of the source can be entered as either a velocity or a redshift. It is used to convert source rest-frame frequencies to their observable (sky) equivalents. The full set of options are:
  - **Velocity**: Upon entering this, the redshift will also be set according to the Doppler Type (velocity definition). For Single Continuum setups, automatic SB generation will set the velocity to zero (in the SB only).
  - **Doppler Frame**: A number of options are available, but the most useful ones are barycentric and lsrk. Heliocentric can also be chosen, but is not currently supported by the telescope control system and during SB generation will be replaced by the nearly identical barycentric (these only differ by a maximum of approximately 12 m/s). If the frame is changed, no conversion is performed of an already-entered velocity/redshift. If lsrk is selected, the user-entered spectral window frequencies are converted to the barycentric frame when calculating tuning solutions. Topocentric is also available, but is not particularly useful given that no astronomical sources have a constant velocity in the frame of the telescope.
  - **z**: Redshift. This is set automatically if a velocity is entered, but the redshift can also be entered and will set the velocity accordingly. For Single Continuum setups, automatic SB generation will set the redshift to zero (in the SB only).
  - **Doppler Type**: This sets the velocity definition (radio, optical or relativistic). Changing this will make the velocity agree with the entered redshift.

- **Target Type**: The supported observing patterns: "Individual pointing(s)" and "1 Rectangular Field". All sources in a Science Goal must use the same Target Type.

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 or the project will not validate. This means that a continuum flux must be entered for a continuum project and a line flux and width must be filled in for a spectral line project. If full polarization is selected, at least one of the line or continuum polarization percentages must also be given.

- **Passive phasing is required**: This is only shown for VLBI and Phased Array projects and is used to signify that the total flux of the source being observed is not sufficient to allow phasing of the array using that source and thus that an additional calibrator must be used. The continuum flux limits are 0.35 Jy for Band 1, 0.5 Jy for Band 3 and Band 6, and 0.7 Jy for Band 7. For spectral line observing the flux thresholds are calculated using the formula reported in the Proposer's Guide. If this is selected, a specific ("fixed") phase calibrator must be defined in Calibrator Setup.

- **Peak Continuum Flux Density per Synthesized Beam**: The expected flux density per synthesized beam of the source continuum. The weakest component that is to be detected should be entered for each source.

- **Continuum Linear Polarization**: The expected degree of **linear** polarization for the source, expressed as a percentage of the peak continuum flux. The polarization of the weakest component should be entered. Note that if the polarization percentage is <0.1 per cent, then the OT will issue a validation error as it will not be possible to detect it reliably.

- **Continuum Circular Polarization**: As above except for circular polarization. A different limit of 1.8 per cent is applied.

- **Peak Line Flux Density per Synthesized Beam**: The expected peak flux density per synthesized beam of the line emission. The weakest component that is to be detected should be entered for each source. If the line is seen in absorption against a continuum, enter the depth of the line as a positive quantity.

- **Line Linear Polarization**: The expected degree of **linear** polarization for the source, expressed as a percentage of the peak line flux. The same polarization limit (0.1 per cent) applies as for continuum.

- **Line Circular Polarization**: The same as continuum circular polarization, but for spectral lines.

- **Line Width**: The expected line width for the lines in this Science Goal (FWHM). The narrowest line that is to be detected should be entered for each source. The line width must be in velocity units. This parameter is also shown for VLBI spectral line observing where it is used to ensure that the line falls within the VLBI spectral window.

If observing the sun, there will only be two choices:

- **Quiet Sun**:

- **Active Sun**:

To compensate for the sun's prodigious flux density, solar observations will often make use of a special observing mode known as mixer debiasing. Which mode will be used will depend on the level of solar activity and the frequency band.

5.2.3 Field Center Coordinates

This panel is visible if Individual Pointing(s) has been selected in the Source panel. The number of pointings that can be defined is nominally 150 per Science Goal, distributed between multiple sources. In practice, more pointings can be created if the source list can be split into multiple clusters. It is possible to define multiple pointings per source, but each one must overlap such that they form a single mosaic. If multiple mosaics are required, they must be placed in separate Field Sources.

- **Coords Type**: Field centre in relative or absolute coordinates. Relative positions are offset from the source coordinate and are recommended. Absolute coordinates can be entered for non-solar-system objects, but will be converted to offsets from the source coordinate during SB generation as absolute coordinates cannot be used with the telescope control system.

- **Array Type**: If both the 12- and 7-m Arrays are required, this allows the user to choose which array's pointings to display.

- **Offset Unit**: If relative coordinates have been selected, set the unit of the offset (usually arcsec).

- **#Pointings**: A count of how many pointings have been defined.

- **RA** and **Dec**: The position of each pointing should be entered in this table, usually relative to the source coordinate. Absolute coordinates are also possible, but are not recommended. No pointing can be more than 5 degrees away from the source coordinate.

At the bottom of the panel are buttons which allow a user to add and delete pointings manually, as well as to reset to a single pointing at the source position. It is also possible to import and export pointings from and to an external ASCII file. The file format is very flexible and allows a user to write out the pointing positions in either offset or absolute coordinates and will automatically do the conversion between the two i.e. one can export in a different system to what is displayed. An example of the format for absolute coordinates in sexagesimal is shown here:

```
RA , Dec, Coordinate Type, Coordinate Units
--   This signals end of the header
 04:31:38.4369, 18:13:57.651,Absolute,Sexagesimal
 04:31:40.5426, 18:13:57.650,Absolute,Sexagesimal
 04:31:36.3312, 18:13:57.650,Absolute,Sexagesimal
```

The "Absolute" coordinate type can be combined with the units "Sexagesimal", "Degrees" or "Radians", whilst "Offset" pointings can be defined in "Arcsecs", "Arcmin" or "Degrees". Both the unit and coordinate type are case-insensitive. Galactic coordinates are not supported.

5.2.4 Rectangle

This panel is only visible when "1 Rectangular Field" is selected in the Source panel. It is possible to define multiple sources, each of which uses a rectangular field pattern. To do this, one must start with only a single source in the Science Goal. This can be set up as a rectangular mosaic and any further sources that are defined will be forced to use rectangular field patterns.

For each rectangle, the OT will calculate a mosaic pattern for the 12- and 7-m Arrays based on the spacing parameter. A larger version of the user-drawn rectangle will be used for raster scanning with the TP Array. A total of 150 12-m Array pointings is allowed, summed over all rectangles.

- **Coords Type**: Field centre in absolute or relative coordinates. Relative positions are offset from the source coordinate and are recommended. Absolute coordinates can be entered, but will be converted to offsets from the source coordinate during SB generation as absolute coordinates cannot be used with the telescope control system.
- **Field Centre Coordinates (Relative)**
  - **Offset(Longitude)**: Longitudinal offset of the centre of the rectangle from the source coordinate.
  - **Offset(latitude)**: Latitudinal offset of the centre of the rectangle from the source coordinate.
- **Field Centre Coordinates (Absolute)**
  - **Sexagesimal display?**: View the coordinates in sexagesimal or decimal degrees.
  - **RA**: The R.A. coordinate of the centre of the rectangle.
  - **DEC**: The Declination coordinate of the centre of the rectangle.
- **p length**: Length of one side of the rectangle. For a rectangle with zero rotation, this refers to the horizontal axis.
- **q length**: Length of the other side of the rectangle.
- **Position Angle**: Position angle of the "p" side of the rectangle from the horizontal direction.
- **Spacing**: Distance between mosaic pointings. This can be specified in arcsec or in fraction of the antenna beamsize, the latter being the default. Nyquist spacing ($\lambda/\sqrt{3}D$ where D is the antenna diameter) is assumed and should usually be selected, unless the sources being observed are relatively small. The spacing is usually shown as a fraction of the antenna beamsize ($1.13\,\lambda/D$) and thus in these units is approximately equal to 0.51. If Nyquist sampling is not used, the reasons for this should be given in the Technical Justification node, but values between 0.7 and 0.8 are fairly typical for observing wide-fields of relatively small sources. A button is provided to reset to the Nyquist value.

- **#Pointings**: The number of pointings calculated by the OT is displayed, for the 12- and (if required based on the Control & Performance parameters) 7-m Arrays. The number of 12-m pointings is not shown for SACA setups.

A button is provided to export the pointings (12-m and 7-m Array) to an ASCII file on disk. If desired, this can be used as the basis of a set of individual pointings that can be read into the Field Source.

5.2.5 TP Regional Mapping

It was previously the case that solar observing with the TP Array would only produce maps of the full solar disc. It is now, however, possible to *also* obtain TP imaging of the area of interest on the Sun's surface i.e. that imaged by the interferometric array. The TP regional mapping area will be centred on the interferometric mapping position.

- **TP Mapping**: Here you select whether you want the previous default (map of just the full solar disc) or whether you also require a TP map of the interferometric mapping area.
- **Pattern Type**: The TP mapping area can be observed in different ways and currently double-circle or rectangular Lissajous patterns are foreseen. Only double circle is currently available.
- **Diameter**: For the double-circle pattern, the only parameter required is the diameter of the area to be mapped and this should be somewhat larger than the area covered by the interferometric observations.

5.3 Spectral Setup

This contains fields to specify the frequency setup of the observations i.e. the frequencies and bandwidths of the spectral windows.

5.3.1 Spectral Type

- **Spectral Type**: The kind of spectral type observations. Choices are: "Spectral Line", "Single Continuum", or "Spectral Scan". The display in the next panel is configured depending on the selected option.
- **Produce image sidebands**: Bands 9 and 10 are DSB receivers for which special processing (90-degree Walsh switching – not available for TP observations) is required to produce both sidebands. This is particularly useful for wide-bandwidth modes such as Single Continuum and Spectral Scan as it doubles the bandwidth and is therefore always enabled. It is also enabled by default for Spectral Line, but can be disabled by the user. It is common to refer to the spw that is defined in the table as the "signal" and the other as the "image". In order to select this mode, a spw in either Band 9 or 10 must first be created and all spws must have the maximum bandwidth of 1875 MHz.
- **Polarization**: Options are XX, DUAL (XX and YY) or FULL (XX, YY, XY and YX), where X and Y are the linear orthogonal polarizations detected by the ALMA receivers. Full polarization should be chosen if a measurement of the source polarization (magnitude and position angle) is desired, but is not yet available for Bands 8, 9 or 10. Full polarization is available for the Stand-alone ACA (except for Band 1 observations) but only with single pointings.

5.3.2 Spectral Setup Errors

This panel will displays errors and warnings for the spectral specifications, if any. Note that it is often the case that not all sources have errors (due to different velocities and therefore tuning solutions) and the error will not be shown unless the source is selected in the source table at the bottom of the Spectral Setup page.

5.3.3 Spectral Line

Four panels for each baseband will be visible and up to four spectral windows (spw) 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 is known as the Representative Window. 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 beamsize drawn in the Visual Spatial Editor and is also used to work out the time estimate for the Science Goal.

For each baseband, the following buttons are available:

- **Add spectral window centred on a spectral line**: This opens the Spectral Line Picker which allows a huge list of transitions to be searched. For each line selected, a spectral window will be added to the table centred on the line and the transition information filled in.
- **Add spectral window manually**: This adds a blank row to the table that can then be completed manually.
- **Delete**: Delete the selected row from the table.
- **Show image spectral windows**: If 90-degree Walsh switching has been selected, the details of the image spws can be displayed by clicking here.

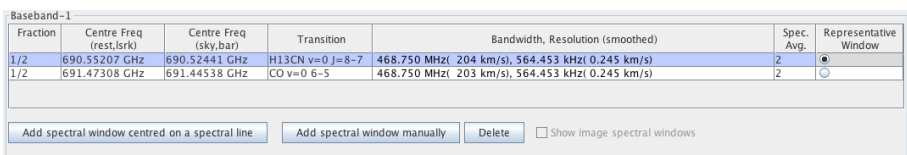

Figure 5.1: The spectral window table for a single baseband. Two spectral windows have been defined, each of which take up half of the available correlator capacity. Note that each has the same spectral resolution (this must be the case) and that the bandwidths are proportional to the assigned fraction. Further note that if there were different spectral averaging factors per spectral window, the spectral resolutions would not appear to be the same, although the bandwidths would still indicate the chosen fraction.

The spectral window table (Fig. 5.1) has the following columns. Most accept input by being double-clicked.

- **Fraction**: Each baseband can currently only support a single correlator mode i.e. a bandwidth and number of channels, where the latter is 8192 for high-resolution modes (FDM) and 256 for low-resolution (TDM). These channels can be spread over the chosen number of polarization products and, from Cycle 2, be split into multiple spectral windows. This splitting is indicated using the Fraction parameter where e.g. a factor of 1/2 indicates that the spectral window should contain half of the maximum number of available channels. For dual-polarization and FDM, a factor of 1/2 indicates that the channel should contain 8192/2/2=2048 channels. As each mode has a different total bandwidth, spectral windows with different bandwidths can therefore be created. Up to four spectral windows are allowed per baseband and thus only the values 1, 1/2 and 1/4 are appropriate. Depending on what fraction is selected, the available bandwidths and spectral resolutions in the drop-down list change. As each spectral window stems from the same correlator mode, each must have the same spectral resolution (before spectral averaging).
- **Centre Freq Rest**: The centre rest frequency of the window. This can be set for each spectral window separately by double-clicking on the table cell, but the total extent of each spectral window must lie fully within the total extent of the baseband (2 GHz).
- **Centre Freq Sky**: The centre sky frequency of the currently selected field source i.e. the rest frequency corrected for the source velocity. If lsrk was given as the Doppler frame, the sky frequency will have been converted to the barycentric frame. Otherwise, no frame conversion is made. Sources are selected using the Targets table (located at the bottom of the Spectral Setup editor page and described in Section 5.3.7).

- **Transition**: A standard name to identify the purpose of the spectral window. Some kind of label identifying the main goal of this spectral window must be entered. The Spectral Line Picker will automatically enter the name of the chosen transition. Enter "Continuum" if the spw is to be used.
- **Bandwidth, Resolution**: The bandwidth and spectral resolution of the spectral window. Only allowed modes may be chosen from a drop-down list and, within a baseband, each must have the same spectral resolution (before spectral averaging). The resolution is calculated assuming Hanning smoothing. This is applied by default to the reported spectral resolution, as is the value of the spectral averaging factor. TDM correlator modes are shown in bold font and are usually used to observe continua or broad spectral lines. For dual polarisaiton, not only 2bit but also 4bit correlator modes can be selected, but only one 4bit spectral window per baseband is allowed.
- **Spec. Avg.**: Spectral averaging factor. This can be any power of two up to a maximum value of 16 and can be useful for reducing the correlator output data rate – if the average data rate exceeds a maximum value (a different value for the 64-input and ACA Correlators) the project will not validate. The default value is 2 as this halves the data rate whilst only degrading the spectral resolution by ∼15 per cent (the non-linearity is due to Hanning smoothing also being applied in the correlator). Spectral averaging can be turned off, but this can lead to very high data rates if many FDM spws are defined, and particularly if 90-degree Walsh switching is also used. The value chosen will be reflected in the reported spectral resolution. TDM spectral windows cannot be spectrally averaged.
- **Store Image**: If 90-degree Walsh switching has been selected, not all image spws must be written out by the correlator. If the image is not required for a particular spw, it can be de-selected here. This will reduce the data rate out of the correlator.
- **Representative Window**: Select one of the spectral windows to set the Representative Frequency. This is the parameter that together with the sensitivity requirement sets the required time and is therefore very important. If the spectral setup lies in areas of variable atmospheric opacity, which spectral window is set as the representative one can greatly influence the time estimate.

The value of the Representative Frequency is displayed below the table of spectral windows. Its value 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. *For spectral line setups this is defined in the rest frame of the source.* This is so that sources with different velocities end up with the appropriate Representative Frequency in the observed frame.

Spectral line observing with VLBI is significantly different. At the moment it is only possible to carry out line observing in Band 1, 3, 6 and 7. For Band 1 and Band 3, baseband 1 needs to be in VLBI mode, i.e., its bandwidth must be 1875 MHz, and only one spectral window is allowed there. For Band 6 and Band 7 at least one of the basebands must be in VLBI mode (but not necessarily baseband 1) and only one spw is allowed there. Spectral windows can be added to the other basebands and their properties can be freely edited – VLBI data will only result from the VLBI spw though. It is also necessary to enter a date for the observation in the time-constraint interface (Control & Performance) in order for the OT to check that the line will be observable.

5.3.4 Single Continuum

This allows a maximum-bandwidth setup to be defined using only a single receiver band or frequency. Upon choosing a band, the OT will automatically set the spectral window frequencies to recommended defaults, such that the sensitivity is maximised. In Band 6, this involves avoiding the inner portions of the sidebands as these are somewhat (∼20 per cent) noisier. See the Technical Handbook for more details. In receiver bands 3 to 8 two spws are placed in each sideband and the total bandwidth is 7.5 GHz. For Bands 9 and 10, 90-degree Walsh switching is enabled allowing four spws per sideband and a total bandwidth of 15 GHz. If this is selected, the image frequencies of each spw can be seen by clicking the "Show image spectral windows" button underneath each baseband.

It is possible to change the absolute positions of the spectral windows by changing a single parameter, the average frequency of the setup, but the relative separations remain the same. A low-resolution correlator mode (TDM) is chosen by default for each spectral window.

- **Receiver Band**: Selecting a band will set up default spectral window frequencies.
- **Sky Frequency**: This is the average frequency of the defined spectral windows and more-or-less corresponds to the value of the first local oscillator (LO1). There is a default for each band, but this can be changed here by entering a frequency in the observed (sky) frame. It is possible to reset to the band default frequencies using the button provided.
- **Rest Frequency**: The rest frequency corresponding to the sky frequency is displayed for reference only. It corresponds to whichever source has been selected in the Targets table at the bottom of the Spectral Setup page.
- **Correlator Mode**: Although the default is to use a low-spectral-resolution correlator mode (TDM), higher spectral resolution can also be selected. This will use FDM mode, still with a bandwidth per spw of 1875 MHz but with many more channels (4096 when using dual polarization). This can be useful for e.g. removing spectral lines during continuum data analysis but results in a much larger dataset and should only be used when really necessary.

The value of the Representative Frequency is displayed below the table of spectral windows. Its value 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.

Single Continuum is currently enforced for polarization mosaics and all solar observations. In these cases there is also no possibility to change the spw frequencies from their defaults.

5.3.5 Spectral Scan

It is possible to define a complicated setup involving multiple tunings that are meant to cover a contiguous range in frequency using the spectral scan interface. Given a start and stop frequency, and a correlator mode, the OT will devise a set of tunings that achieve the requested frequency range. The tunings are overlapped to ensure that bad edge channels can be flagged without leading to gaps in the combined spectrum. The overlaps are greatest for the 1875 MHz-wide spectral windows (∼170 MHz) and smaller (∼31 MHz) for the remainder.

- **Requested start frequency (sky)**: Frequencies can only be entered in the sky (observed) frame. The OT will start placing its spectral windows at this frequency.
- **Requested stop frequency (sky)**: The OT will attempt to achieve this frequency by creating up to five tunings. The OT will rarely achieve this exact frequency as there are fixed gaps between each tuning and each tuning implies a fixed amount of extra frequency coverage.
- **Requested range (rest)**: The requested range is also shown in the rest frame of the first target defined in the Field Source editor. The OT will warn if the requested range was not achieved.
- **Achieved scan range (sky)**: In general, the OT will not achieve the exact frequency range requested and this is displayed here.
- **Bandwidth**: One of four correlator modes (the four widest available) should be chosen from the drop-down menu. The displayed values of spectral resolution include Hanning smoothing and spectral averaging.
- **Spectral averaging**: A single spectral averaging factor can be applied to all spectral windows.
- **Representative frequency (sky)**: The default value (centre of requested range) can be changed.

Once enough information has been added, the OT will calculate a tuning setup and display the derived spectral windows. Spectral scans are only allowed for sources observed with a single pointing and cannot observe in full polarization. Starting from Cycle 10, TP Spectral Scans are also allowed.

5.3.6 Rest Frequencies

This panel contains a link to a version of the Spectral Line Picker (Rest Frequency SLP or RFSLP) that allows the user to enter the rest frequencies that will be observed. These will be written to the SB at Phase 2 and used during data reduction to set the velocity scale and as part of archive searches to identify relevant data.

When this tool is first opened, it will automatically include any rest frequencies that were used to define a spectral window. It will also ask the user if they would like to add the frequencies of any overlaid lines that fall into spws. Therefore, we recommend that this tool be used once the spectral setup has been fully defined. This default list of rest frequencies can then be edited i.e. rest frequencies added or deleted. Adding or deleting spws and re-opening the tool will update the list of rest frequencies accordingly.

If a spectral window is moved such that a defined rest frequency no longer falls within an spw, this will cause a validation error and the offending line will be highlighted in red if the RFSLP is opened. It should be deleted and the tool closed. This includes spws that were created using the SLP and these must be deleted and re-entered if the line used to define the spw no longer falls within it. Users will find that Science Goals which have been extensively edited and used as the basis for new projects, perhaps in different bands, now give such validation errors.

If it is desired to start again with a revised spectral setup and/or additional overlaid lines, all rest frequencies should be deleted and the rest-frequency tool re-opened.

5.3.7 Targets

This panel contains a table of the sources that were defined in the Field Setup node. Clicking on one will update various aspects of the Spectral Setup page, including the sidebands and spectral windows displayed in the Visual Spectral Editor, as well as the velocities displayed in the spectral window table.

5.4 Calibration Setup

5.4.1 Goal Calibrators

For the vast majority of projects, standard observatory calibration observing strategies will be perfectly adequate and the first (default) option should be selected. The options are:

- **System-defined calibration**: The default calibration strategy whereby a single observation of a bright quasar is used to calibrate both the flux scale and the bandpass. A phase calibrator will also be scheduled, as well as a polarization calibrator if full polarization was requested.
- **System-defined calibration (force separate amplitude calibration)**: This is similar to the first option, but differs in that the amplitude (flux) calibration will be done using a separate observation of a solar-system object if one is available at the time of SB execution. If this is not the case, a grid source will be observed instead. Only select this if particularly high amplitude accuracy is required.
- **User-defined calibration**: If this option is selected, the user can define their own calibration sources. This is not recommended and should only be selected if you really know what you're doing, or if passive phasing for VLBI has been selected in which case a fixed phase calibrator must be defined. All user-defined calibrations must be fully explained in the Technical Justification. The options are:
  - **Add Query**: In this case, the source is chosen at SB execution time based on some criteria (usually a search radius around a position and perhaps a minimum flux constraint) entered by the user.
  - **Add Fixed Calibrator**: Using this interface a specific calibrator source can be chosen when creating the proposal.
  - **Delete**: Clicking on a row will allow it to be deleted using this button.
  - **Delete All**: This button is most useful for restarting a calibration setup.

5.4.2 Astrometry

If better positional accuracy is required than provided by ALMA by default (due to use of a standard calibration scheme or default observing conditions), this can be indicated using the controls in this panel.

Currently, an astrometry mode has not been formally commissioned but it would still be useful if PIs could indicate if enhanced positional accuracy is required by clicking the appropriate button. If this is done, a Technical Justification box must be completed any should include any relevant details including why the enhanced accuracy is required. Users should consult the Proposer's Guide and Technical Handbook for more details.

It is not possible to select enhanced accuracy for solar observations, Large Proposals, the Stand-alone ACA or for VLBI.

5.4.3 DGC Override

If the OT decides that Differential Gain Calibration (DGC) is required, privileged users (i.e. observatory staff) will be able to override this and turn DGC off using the checkbox displayed here. It is not possible to force DGC execution if the DGC criteria (lack of a suitable calibrator) are not met.

5.5 Control and Performance

5.5.1 Configuration Information

At the top of the page, a panel (not shown for VLBI or Phased Array projects) shows array and telescope configuration information. 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**: The FWHM of both the 12- and 7-m dishes. This roughly sets the field of view of a single telescope pointing. Sources larger than this, or multiple sources spread over a larger area, must be mosaiced together using multiple pointings.
- **Number of antennas**: The number of atennas assumed for each of the arrays. These numbers are also set by default in the ALMA Sensitivity Calculator.
- **Longest baseline**: The maximum baselines available for the most compact and extended 12-m Array configurations, as well as the ACA 7-m Array. The baseline lengths are a function of receiver band as the larger configurations cannot be observed at higher frequencies. All baseline lengths are *unprojected* i.e. they are not a function of source declination. Projection effects are though taken into account when calculating the synthesized beamsize.
- **Synthesized beamsize**: The synthesized beam sizes for the corresponding maximum baselines. This number is dependent on the source declination, or the average declination if there is more than one source. The best angular resolution is possible when observing a source at the same declination as the latitude of the observatory (-23 degrees). As the magnitude of the declination difference increases, the angular resolution deteriorates for a given configuration. If the sources have been split into multiple clusters, the value reported for the most compact configuration corresponds to the cluster which produces the largest beamsize. Likewise, the most extended configuration will correspond to the smallest beamsize possible out of all the clusters.
- **Shortest Baseline**: The minimum baselines available for the most compact and extended 12-m Array configurations, as well as the ACA 7-m Array. The baseline lengths are a function of receiver band as the larger configurations cannot be observed at higher frequencies. All baseline lengths are *unprojected* i.e. they are not a function of source declination. Projection effects are though taken into account when calculating the maximum recoverable scale.
- **Maximum recoverable scale**: The largest structures that it is possible to image with the most compact and extended configurations. Like the angular resolution, this is also declination dependent.

5.5.2 Desired Performance

Based on the configuration information, the user should then enter desired performance parameters in the bottom panel. These will determine which configurations are required (including ACA) and how much time is required. The following fields are included:

- **Desired Angular Resolution**: A number of options are available to request the desired angular resolution or synthesized beam size i.e. the finest detail that will be visible in the map of the source. These are:
  - **Single**: A user may request a single value of angular resolution, although in practice a value within approximately ±20 per cent of this will be delivered.
  - **Range**: If the science could be done using one of several nominal configurations, this can be indicated by entering a range. In principle this increases the chances of a project being observed as it gives the observatory more flexibility when scheduling. Note that if the possible configurations include a mixture of long-baseline and smaller configurations, the long-baseline possibilities will be disregarded as the observing overheads are much higher.
  - **Any**: By selecting this the user indicates that the SBs could be observed on any of the available configurations. As with a specific range of values, long-baseline configurations will not be considered by the OT or by the Scheduler.
  - **Stand-alone ACA**: Instead of entering an angular resolution, the Stand-alone ACA is selected using this option. No 12-m configuration will be selected, but the TP Array might be added depending on the requested LAS. This is the only option if the proposal is for the ACA Supplemental Call.

  Any value that is entered must lie in the range provided by the available configurations i.e. given in the Configuration Information panel. Unless the Stand-alone ACA was requested, the OT will select one or more 12-m configurations according to the various restrictions mentioned above. If any of these require additional (smaller) array configurations (including the 7-m and TP Array) to achieve the source LAS, only those combinations that require the smallest number of configurations will be considered. An angular resolution is never entered for VLBI proposals.

- **Largest Angular Structure in source**: The angular extent of the largest components in the source that need to be imaged. If this parameter (also sometimes referred to as the Largest Angular Scale – LAS) is smaller than the max recoverable scale of the selected 12-m configuration, smaller configurations must be added, if possible. For example, multiple 12-m configurations, the ACA 7-m and Total Power Arrays might be necessary to reliably image the indicated size of the source structure. Various restrictions exist including that the very largest 12-m configuration cannot be combined with anything else. If the source size is very small, a value of zero can be used. The OT will also issue a validation error if the LAS is larger than the field of view as defined by the arrangement of pointings or the dimensions of a rectangle in the Field Setup. This parameter is not shown for VLBI observations.

- **Desired sensitivity**: The sensitivity goal 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 "Individual Pointing(s)", it is the value per pointing, even if a custom mosaic has been defined. For a continuum observation, this should be the sensitivity desired in the final continuum map. For a line observation, the sensitivity should be that desired in a single channel map, where one usually wants to have several channels across each line profile. If the angular-resolution choice was "Any", the sensitivity must be entered in flux units. This is not shown for VLBI or solar observations.

- **Equivalent sensitivity**: If the requested sensitivity were in flux units then the OT will also display the equivalent in temperature units, and vice versa. Things are more complicated if a range is entered. A desired sensitivity in flux units will be converted to the equivalent temperature for the angular resolutions of the smallest and largest nominal configurations within the range. If the user-requested value is in kelvins, however, the flux-equivalent is first shown for the largest possible nominal configuration. As this flux sensitivity is what the observatory will deliver regardless of what configuration is actually scheduled (the time estimates are always based on the flux sensitivity) it is then converted into a temperature-equivalent using the coarsest requested angular resolution.

- **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 or a user-defined value can be entered.The effective channel width of the representative window ("RepWindowEffectiveChannelWidth") is the default and will use the narrowest effective channel width (including Hanning smoothing and spectral averaging) of the spectral window chosen as the sensitivity driver for the observations. Please refer to the Spectral Setup section of the Technical Handbook for a definition of the effective channel width.This is usually a good choice for observations of spectral lines. If additional smoothing is envisaged post-observation, then a user-defined value can be entered - velocity units are preferred. For continuum observations where the spectral line interface has been used, the entered value should be the total non-overlapping bandwidth that is free from significant line emission.The "AggregateBandWidth" option will calculate the total non-overlapping bandwidth automatically and is the only option for Single Continuum setups. "FinestEffectiveChannelWidth" refers to the smallest effective channel width of any of the defined spectral windows.This is not shown for VLBI observations.

- **Time Estimate**: 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) for each array required. For VLBI observations, the user must enter their own time estimate, including calibration, for the whole science goal. If the Sun is being observed, only the on-source time should be entered.

- **Override OT's sensitivity-based time estimate?**: If complicated and bright sources are being observed, the sensitivity target might not be reached due to limited *uv*-coverage. Alternatively, a user might not be interested in sensitivity, but rather in observing a source for a fixed amount of time in order to follow source variability. In either case, the sensitivity-based time estimate can be overridden here, but this must be rigorously justified. The time entered must be equal to the total time required for all the arrays, including calibration and overheads. This option is probably only useful for experts and it is not expected that it will be used very much. This is not shown for VLBI or solar observations.

- **Simultaneous 12-m and ACA observations**: If the observations require a single 12-m configuration and the 7-m Array only, it is possible to request that these be observed simultaneously. This is thought to be most useful for the planetary community and will result in the 7-m time being set to the same as that of the 12-m Array. Please note that configurations C-7, C-8, C-9, and C-10 are however excluded from simultaneous observing, as they cannot be paired with ACA.

- **Are the observations time-constrained?**: Clicking this reveals an interface for setting various scheduling constraints for the observations. If time-constrained observing is selected, it must be justified in the Technical Justification node. Currently there are two types of time constraint:

  - **Single visit**: Multiple time windows can be entered, during **one of which** the SG should be executed. It is possible to import these windows from an external ASCII file. Each visit should go on a separate row and each row should contain two comma-separated values of format YYYY-MM-DDThh:mm:ss e.g.

    ```
    2015-03-19T01:30:00, 2015-03-19T01:30:00
    2015-03-21T01:30:00, 2015-03-21T01:30:00
    2015-03-23T01:30:00, 2015-03-23T01:30:00
    2015-03-25T01:30:00, 2015-03-25T01:30:00
    ```

  - **Multiple visits**: Multiple dates (either absolute or relative to one of the epochs) at **each of which** the SG should be executed.

5.6 Technical Justification

The technical justification for the various parameters entered by the user into the OT is dealt with in a dedicated node. For most projects, this is split into three main sections. For solar, VLBI and Phased Array observations,

the TJ does not use the sensitivity, imaging and correlator-configuration boxes and instead an additional text box is shown in "choices to be justified" that should cover most aspects of these observations.

5.6.1 Sensitivity

In this section, the OT first presents a number of sensitivity-related parameters based on user input entered elsewhere in the Science Goal. These are designed to help users with the textual discussion of the sensitivity goals to be entered in the free-format text box below. Note that for multiple sources the most restrictive values of the Expected Source Properties are used i.e. the flux of the weakest source and the narrowest line width is assumed. If the OT detects potentially problematic issues, a message will appear in blue text and special attention should be paid to addressing these in the justification text.

The parameters reported by the OT vary depending on the contents of the Science Goal. The full list is:

- The signal to noise ratio (SNR) over the user-requested bandwidth for sensitivity: This calculation divides either the continuum or line flux by the requested rms. The continuum flux is used for single continuum setups (or where the bandwidth for sensitivity is more than twice the line width) and the line flux in the remaining situations. The user is notified if this or any of the other SNR values in the TJ node are less than three.
- The SNR over the aggregate, non-overlapping bandwidth: For spectral line (not single continuum) setups, this calculates the rms that would be achieved over the full, non-overlapping bandwidth (continuum rms) and subsequently the continuum SNR (continuum flux / continuum rms). This assumes that the entire bandwidth is free of spectral lines.
- The SNR over one third of the line width: For any Science Goal that includes line parameters in Expected Source Properties, the OT will calculate the rms over one third of the line width and calculate the corresponding line rms. In order to properly sample a spectral line profile, it is common to have approximately three spectral bins over the spectral line width.
- The ratio of the line width to the bandwidth for sensitivity: Again, if line parameters have been entered in Expected Source Properties, this calculation will be presented. Three spectral points are often placed across each line, although higher values are often used if the shape of the line profile is to be measured. The user is notified if this value is less than three.
- Spectral dynamic range: If both spectral line properties and a continuum flux have been entered, the ratio of the continuum and the line rms are reported as the "spectral dynamic range". The line rms is taken as the requested sensitivity, unless the bandwidth for sensitivity is greater than twice the line width, in which case the rms is that which would be achieved over one third of the line width. The spectral dynamic range is relevant as detecting weak lines against a strong continuum is difficult and requires good bandpass calibration. The OT will issue a warning message if the band-dependent limit is exceeded.

When calculating many of these parameters, the OT will use the time that will actually be observed, rather than the time implied by the sensitivity alone. For example, a minimum time per source is enforced and when calculating the rms over one third of the line width, the OT would use this time if the sensitivity request meant that the limit had not been reached.

5.6.2 Imaging

Discuss the imaging goals of the project in the text box, particularly with regard to the desired angular resolution and source LAS.

5.6.3 Correlator configuration

Here the OT reports some basic parameters of the correlator configuration, specifically the number of spectral resolution elements (including Hanning smoothing and spectral averaging) per line width and the bandwidth

of the Representative Window. In the free-form text box the user should discuss the correlator configuration, particularly with regards to how many resolution elements there will be across each spectral line.

5.6.4 Choices to be justified

If selected by the user, the following user settings will also need to be justified. A free-format box appears for each.

- Non-Nyquist mosaic sampling: Non-Nyquist values are usually used when the scientific goal is to cover a large survey area and large-scale structures are not being observed. Polarization mosaicing may benefit from sampling at higher than the Nyquist frequency.
- Single polarization: Dual polarization is more usually selected and single polarization only used when the highest spectral resolution is required.
- Low max elevation: Sources with low declinations will suffer large atmospheric attenuation and be difficult to schedule because of limited time above the horizon.
- User-defined calibration: As the observatory guarantees appropriate calibration without user input, this must be rigorously justified. For VLBI and Phased Array projects, the choice of phasor should be explained here.
- Override of OT's sensitivity-based time estimate: This may be necessary if you want to monitor a source over a certain time span or if your source has a complicated structure but the sensitivity-based time estimate does not allow for sufficient *uv*-coverage. You must give a detailed justification for the time override, and explain how the new time estimate was calculated. The time override must include calibrations and overheads.
- Time-constrained observing: These imply significant constraints on the scheduling of all ALMA projects and must therefore be fully justified.
- Astrometry: If enhanced positional accuracy was selected, please explain why this is necessary i.e. state the positional requirements with reference to what ALMA provides by default (consult the Proposer's Guide and Technical Handbook for more information).
- Solar Technical Justification: All technical details of solar observations should be discussed in this text box. See the Proposer's Guide for more information.
- VLBI Technical Justification: All technical details of VLBI observations should be discussed in this text box. If passive phasing has been selected then the choice of calibrator must be discussed in the box reserved for that purpose. See the Proposer's Guide for more information.
- Phased Array Technical Justification: All technical details of phased-array observations should be discussed in this text box and there should also be discussion of the post-processing steps. See the Proposer's Guide for more information.
- Passive Phasing Technical Justification: Describe here the source selected to be used for passive phasing i.e. why it is suitable to be used for this purpose. Its brightness and proximity should be discussed.
- High Imaging and/or Spectral Dynamic Range Technical Justification: Describe here why high dynamic range is required and how this can be achieved.

This page was intentionally left almost blank

Chapter 6

Phase 2 Program Scheduling Blocks

Actual observing is done using Scheduling Blocks. Due to their complexity, these are nearly always generated automatically from Science Goals. Privileged users though can create them from scratch or edit their contents. **PIs cannot generate or edit the contents of SBs.**

6.1 Observing Unit Set

Observing Unit Sets contain either other OUSs or one or more Scheduling Blocks. Although an arbitrarily deep nested structure would be possible, in practice all ALMA SBs should be contained in a standard structure of a top-level Science Goal OUS, a Group OUS and a Member OUS – the SBs go in the latter. The following panels are present in all OUSs. Little of the information is yet used.

6.1.1 Basics

The Basics panel contains very basic non-technical information only.

- **ObsUnitSet Name**: A user entered name for this OUS. SB generation will default to standard names and differentiate between the Science Goal, Group and Member ObsUnitSets.
- **Status**: Shows the current status of this particular OUS.
- **Description**: Optional description of the OUSs purpose/contents.

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. Quite probably none of the information in the panel is currently used.

- **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 definitely currently not used:

- **User Priority**:
- **TAC Priority**:
- **Pointing Accuracy**:
- **Bandpass Accuracy**:
- **Polarization Accuracy**:

The remaining three panels, Unit Dependencies, Pipeline Information and Data Processing Parameters are also not used.

6.2 The Scheduling Block

The Scheduling Blocks are the key executable units of a project and contain all the information necessary to execute a single observation. In addition to the SB overview form itself, SB Target details are stored in the 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 Basics

- **SchedBlock Name**: A user-entered name for this SB.
- **Status**: Shows the current status of the SB. These typically go through the sequence, 'NewPhase2', 'Phase2Submitted', 'Ready', 'PartiallyObserved' and 'FullyObserved'.
- **Description**: Optional description of the SB.

6.2.2 Control

The Control panel provides various constraints on the observation, but very few, if any, of the parameters are used at present.

- **MOUS Maximum Total Execution Time**: The maximum total time allowed for multiple SB executions. It is equal to the SB Maximum Execution Time (given in the SchedBlock panel) multiplied by the number of expected executions.
- **MOUS Estimated Total Execution Time**: This is the estimated total execution time for all executions of this SB. During automatic SB generation, it is currently set to the same as the MOUS Maximum Total Execution Time.
- **Array Type**: The array configuration to be used. Options are the 12-m Array, the ACA, the 7-m Array, the Total Power Array and ALMA.

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

- **User Priority**:
- **TAC Priority**:
- **Pointing Accuracy**:
- **Bandpass Accuracy**:
- **Polarization Accuracy**:

6.2.3 Unit Dependencies

For time-constrained observations, it is often the case that one visits are defined relative to others. In this case, this information is conveyed using the Unit Dependencies panel.

- **Dependency List**: This opens an editor which shows the SBs that the one being edited could depend upon. Use of the arrow buttons will allow the requisite dependency to be set.
- **Delay**: How to long to wait after the dependent SB's execution before attempting the one being edited.
- **Margin**:
- **Execution Count**: Not yet used.
- **Expression**: Not yet used.
- **Control Script**: Not yet used.

6.2.4 Preconditions

The Preconditions panel specifies the conditions that must be met before this SB can be executed. It is very unlikely that any of these are yet being used by the observing system and hence we do not give details of what each does.

- **Baseline cal**:
- **Polarization cal**:
- **Max PWVC**:
- **Seeing**:
- **Phase Stability**:
- **Max Wind Velocity**:
- **Min Allowed HA**: It is likely that this will be used from Cycle 7. An obscure note is that hour angles are able to be specified in "user units", the only property where this is allowed in an SB. The user units are basically the standard angles (degrees, radians, arcmin, arcsec and mas) plus hours and "fraction of main beam", the latter of which is no longer used within the OT.
- **Max Allowed HA**: As above.

6.2.5 SchedBlock

- **Standard Mode**: If true, this SB is part of a supported, "standard ALMA observing mode", such as single-field interferometry or interferometric mosaicing. This is set automatically depending on which mode is selected.
- **Mode Name**: The name of the observing mode. Interferometric and total power observing of PI projects normally use "Standard Interferometry" and "Standard Single Dish" respectively.
- **Mode Type**: The type of the observing mode: Observatory, User or Expert. This parameter is set automatically depending on which mode is selected.
- **Execution Count**: The number of times that the SB should be run. Once this is reached it is impossible to execute the SB again so this is often set to a larger number than required.
- **Indefinite Repeat**: The Execution Count can be overridden if this is selected.

- **SB Maximum Execution Time**: Maximum observing time per individual execution of this SB. The execution of the SB will be automatically terminated if this time is exceeded.
- **Obs. Procedure**: Name of the script that will be used to run the observation. Alternatively, the script can itself be entered into the text field. Interferometric and total power observing of PI projects normally use `StandardInterferometry.py` and `StandardSingleDish.py` respectively.
- **Run Quick Look**: If true, as it usually should be, the ALMA Quicklook display will be run during the observation and provide rapid feedback as to the quality of the data.

6.2.6 Advanced Parameters

The Advanced Parameters panel allows the specification of ad hoc parameters ("expert" parameters) that will be passed to the Science Observing Scripts (SOS). The ability to create keyword-value pairs on the fly allows SOS to test new functionality, although some values are set automatically during SB generation. This should be a short-term measure only – each parameter should eventually have its own entry in the APDM i.e. become a "proper" field in the OT. The keyword-value pairs must exactly match what is expected by the script, although they are now case-independent. **This panel is only shown to users who can and have enabled advanced privileges.**

6.2.7 Performance Goals and Scheduling Constraints

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

- **Representative Target**: A Phase 2 program needs a Representative Target in order to validate and generation will usually set this to the first Field Source. The Doppler settings will be set based on the Representative Target.
- **Representative Coordinates**: The coordinates of the Representative Target.
- **Representative Frequency**: This is usually the centre frequency of representative spectral window defined in the Science Goal.
- **Representative Receiver Band**: Band corresponding to the Representative Frequency.
- **Min. Angular Resolution**: This and Max. Angular Resolution are set based on the angular-resolution input in the Science Goal. These fields are read by the automatic scheduler which will consider this SB observable if the angular resolution of the current array at the AOS lies within this range. Many other parameters go into deciding whether an SB is ultimately observed or not.
- **Max. Angular Resolution**: See above.
- **Imaging Dynamic Range**: This shows the highest dynamic range expected in an image made from the data from one of the sources in this SB. The OT calculates this dynamic range for both spectral line and continuum cases and displays the highest of these values. The spectral line rms is that measured over one third of the line width.
- **Spectral Dynamic Range**: This shows the highest spectral dynamic range (continuum flux / line rms) expected for a source in this SB.
- **Spectral Dynamic Range Bandwidth**: The bandwidth that was used to calculate the line rms for the spectral dynamic range. The OT always uses one third of the line width.
- **Largest Angular Scale**: This is the value that was entered in the Science Goal.
- **Nominal Configuration**: This field is for information purposes only and gives the configurations that might be used by the Scheduling software to decide whether the SB can be run or not. The min. and max. angular resolutions (above) determine which configurations are used in practice.
- **Max. Allowed Beam Axial Ratio**: The expected beam axial ratio (major divided by minor axis) should always be less than this value.

6.2.8 Temporal Constraints

If an SB should be observed on one of possible multiple fixed dates, an editor will display each time constraint in this panel.

6.2.9 Observing Groups

This panel shows the currently defined Observing Groups and their index. Their order can be changed using the arrows.

6.3 Observing Groups

ALMA observations are constructed out of Targets (Section 6.4). In order to be observed, each must be placed into an Observing Group (OG) with each OG being observed sequentially. There are usually two OGs, the first ("Calibrators") usually containing amplitude and bandpass calibrators and the second ("Science") the science source and phase calibrator. If the SB contains multiple tunings, each will be placed in a separate Science OG.

Clicking on an OG will show an editor that allows the required Targets to be selected. This contains a column entitled "Doppler Target". This defines which source will be used to convert from rest to observed frequencies and used by the telescope control system to set up the tuning for that OG. The Target which is selected as the Doppler Target is marked with a `D`n in the Project Tree, where n refers to the index of the *Science* tuning group (one-based).

6.4 Targets

A Target is a fundamental building block of an SB and consists of three specific Resources: a Field Source, an Instrument Setup and an Observing Parameters. These are described in more detail below.

6.5 Field Sources

The following panels are visible for each Field Source node. Together with a Instrument Setup and an Observing Parameters, a Target is created which can be used to observe one or more scans during SB execution.

6.5.1 Query Status

Checking this allows a set of search criteria to be defined that will be used at runtime to select a calibrator in real time. Alternatively, it can be used to search the ALMA calibrator database for a specific source.

6.5.2 Field Source

If a Field Source query has been selected, this panel is not used. It contains:

- **Field Source Name**: This should be a unique identifier for the Field Source. It is usually used to describe the purpose of the Field Source e.g. amplitude.
- **Source Name**: The source name – this can be used to automatically complete the source details using the Resolve button. This can potentially add the coordinates, proper motions and velocity information. Please check the information carefully!

- **Choose a Solar System Object**: Selecting this brings up a list of solar-system bodies that are known to the telescope control system. Alternatively, an ephemeris can be entered. "Sun" will require that an ephemeris be attached.

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

  - **System**: FK5 should no longer be selected and will not be supported in the future. Changing between ICRS and Galactic will cause a coordinate conversion to be performed.
  - **Parallax**:
  - **RA**:
  - **Dec**:
  - **Proper Motion RA**: Proper motion in the Right Ascension (cross-declination) direction. Typical units are milliarcsec/yr.
  - **Proper Motion Dec**: Proper motion in the Declination direction.

- **Source Radial Velocity**: The radial velocity of the source can be entered as either a velocity or a redshift. It is used to convert source rest-frame frequencies to their observable (sky) equivalents. The full set of options are:

  - **Velocity**: Upon entering this, the redshift will also be set according to the Doppler Type (velocity definition). For Single Continuum setups, automatic SB generation will set the velocity to zero (in the SB only).
  - **Doppler Frame**: A number of options are available: barycentric, lsrk and topocentric. However, heliocentric should not be chosen as it is not currently supported. Resolving the source details will often cause heliocentric to be set and, if this is the case, automatic generation will convert it to barycentric (these differ by a maximum of approximately 12 m/s). If the frame is changed, no conversion is performed of an already-entered velocity/redshift.
  - **z**: Redshift. Upon entering this, the velocity will also be set according to the Doppler Type (velocity definition). For Single Continuum setups, automatic SB generation will set the redshift to zero (in the SB only).
  - **Doppler Type**: This sets the velocity definition (radio, optical or relativistic). Changing this will make the velocity agree with the entered redshift.

In the source properties table that follows frequency, flux and diameter can be provided. If the source has been selected from the ALMA Calibrator Database, these details will be filled in automatically. Finally:

- **Visible Magnitude**: Visible magnitude for the source (used in optical pointing). Not currently used.

- **Use Reference**: If checked, a reference position can be defined.

6.5.3 Reference Position (Offset)

Up to two reference positions can be specified if this option has been selected in the panel above, but only one of these is currently used. The purpose of this position differs depending on the context. For interferometric SBs it is used to determine the position used for the system temperature measurement – by default it is set to a 2 arcmin in longitude only. Solar SBs use a value of 2 deg. For TP SBs it is also used for the "OFF" position, an area of sky that should be devoid of emission. This is by default set to the edge of the scanning area, but should be replaced with a position known to contain no signal.

The parameters are:

- **Reference Coordinates**:

- **Coords Type**: Choose between absolute or relative coordinates. All offsets are relative to the source coordinate i.e. not to the requested pointing positions which can themselves be offsets from the source coordinate. Absolute coordinates are now supported. Only ICRS and horizon offsets are currently supported. If FK5 or azel are selected, these will be interpreted as ICRS and horizon respectively.
  - Absolute offset inputs:
    - **System**:
    - **RA**:
    - **DEC**:
  - Relative offset inputs:
    - **System**:
    - **Offset(Longitude)**: Relative to the source coordinate.
    - **Offset(Latitude)**: Relative to the source coordinate.

- **Integration Time**: Time spent integrating per visit. Set, but almost certainly not used by the telescope control system.
- **Cycle Time**:
- **Sub Scan Duration**: Set, but almost certainly not used by the telescope control system. It must though be an integer multiple of both the integration duration and 48 ms or else the project will not validate. If an approximation is entered (the real value normally has lots of decimal places), a button is available to adjust this to the nearest legal value.

6.5.4 FieldPatternEditor

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 defined. The available patterns are:

- Point – used for most interferometric observations i.e. where an antenna is stationary whilst integrating.
- Fill – used for fast scanning a rectangular area using a Lissajous figure. Intended for use with a single dish.
- Rectangle – defines an area which can be raster scanned by a telescope, usually a single dish. It can also be used to create a mosaic of single pointings.
- Cross – not currently supported.

6.5.4.1 Point

This interface consists of a table where the list of pointings should be added. Each will be observed one by one, each for the appropriate subscan duration, until the total integration time has been reached. The inputs are:

- **PointingPattern: Offset**: Tick if the pointing pattern position is an offset relative to the source position. If not, absolute positions are used.
- **Offset Unit**:

These are followed by the table, above which is reported how many pointings have been created.

6.5.4.2 Fill

- **Pattern Centre Coords**:
  - **Coords Type**: Choose between absolute or relative (to the Field Source) coordinates. Only FK5 J2000 and horizon systems are currently supported.

        - Absolute offset inputs:
            - **System**:
            - **RA**:
            - **DEC**:
        - Relative offset inputs:
            - **System**:
            - **Offset(Longitude)**:
            - **Offset(Latitude)**:

- **Lat. length**:
- **Sampling length**:
- **Long. length**:
- **Orientation**:
- **Scanning Coordinate System**:

6.5.4.3 Rectangle

- **Pattern Centre Coords**:
    - **Coords Type**: Choose between absolute or relative (to the Field Source) coordinates. Only FK5 J2000 and horizon systems are currently supported.
        - Absolute offset inputs:
            - **System**:
            - **RA**:
            - **DEC**:
        - Relative offset inputs:
            - **System**:
            - **Offset(Longitude)**:
            - **Offset(Latitude)**:
- **Lat. length**: Length of one side of the rectangle.
- **Lat. samples per beam** (non-editable): A measurement is taken once every integration duration and the sampling velocity should be such that the antenna beam is sufficiently sampled. If the scanning direction is in the latitudinal direction, there should be at least 5 samples per beam and a warning will be issued if this is not the case. If instead the telescope is being scanned longitudinally, the sampling rate should be at least $3\,\mathrm{beam}^{-1}$.
- **Orthogonal step**: For raster scans – step size in the direction orthogonal to the scan direction.
- **Long. length**: Length of the other side of the rectangle.
- **Long. samples per beam** (non-editable): A measurement is taken once every integration duration and the sampling velocity should be such that the antenna beam is sufficiently sampled. If the scanning direction is in the longitudinal direction, there should be at least 5 samples per beam and a warning will be issued if this is not the case. If instead the telescope is being scanned latitudinally, the sampling rate should be at least $3\,\mathrm{beam}^{-1}$.
- **Scan Direction**: For raster scans – the scanning direction for the raster, either in longitude or latitude.
- **Scans per map** (non-editable): The number of rows in the raster map along which the telescope scans.
- **Unidirectional Scan**: For raster scans – if checked, each scan will be made in the same direction.

- **Scan Velocity**: This cannot be set by the user.
- **Orientation**: Position angle of the rectangle.
- **Scanning Coordinate System**:
- **Setup Mosaic (Optional)**: If desired, the above-entered rectangle *size* can be converted to a pointed mosaic. After filling in the following parameters and performing the conversion, the Field Pattern editor will revert to Point and the list of derived pointings will be shown.
  - **Frequency**:
  - **Overlap**:
  - **Spacing**:
  - **Antenna**:
  - **Layout Type**: Triangle patterns are usually used.

6.5.4.4 Cross

This field pattern is not yet supported.

- **Pattern Centre Coords**:
  - **Coords Type**: Choose between absolute or relative (to the Field Source) coordinates. Only FK5 J2000 and horizon systems are currently supported.
    - Absolute offset inputs:
      - **System**:
      - **RA**:
      - **DEC**:
    - Relative offset inputs:
      - **System**:
      - **Offset(Longitude)**:
      - **Offset(Latitude)**:
- **Lat. length**: Length of one arm of the cross.
- **Long. length**: Length of the other arm of the cross.
- **Initial Scan Direction**: Choose which arm of the cross to begin with.
- **Scan Velocity**:
- **Orientation**: Position angle of the cross.

6.6 Instrument Setup

The following panels are visible for each Instrument Setup node.

6.6.1 Spectral Spec

- **Spectral Spec Name**: This should be a unique and descriptive identifier for the Spectral Spec.
- **Receiver Band**: Once a baseband has been defined, the receiver band and type (2SB, DSB, SSB) will be set automatically.
- **Add Total Power with square law detector to this correlator setup**: Not used.

6.6.2 Switching

No switching possibilities are yet implemented at the telescope, but the basic interface is already in place in the OT. The options are:

- NO_SWITCHING
- NUTATOR_SWITCHING
- FREQUENCY_SWITCHING

As none of these options are yet enabled, discussion of the inputs is deferred to the future.

6.6.3 Correlator Configuration

- **Integration Duration**: This sets the averaging interval of the data written by the correlator (to the ASDM). If an approximation is entered (the real value normally has lots of decimal places), a button is available to adjust up to the nearest legal value. Typical values are ∼2 s for TDM correlator modes and ∼6 s for FDM. For long-baseline FDM SBs, the OT will attempt to use 2 s, but will drop this to 3 or 4 s (the latter in the case of 90-degree Walsh switching) if the data rate exceeds the 70 MB/s limit.
- **Channel Average Duration**: This sets the averaging interval of the channel averaged data. For the 64-input Correlator, this must be a multiple of the dump duration. Other restrictions apply for the ACA Correlator. For NORMAL accumulation it must be a multiple of 16 ms, whilst for FAST it must be 1, 2, 4, 8, or a multiple of 16 ms. Also, it cannot exceed 1024 ms and, if <0.5 s, must be equal to the integration duration. Otherwise, the channel average and integration durations must be equal. Approximations can be automatically adjusted up to the nearest legal value.
- **Atmos. Phase Correction Data To Save**: It is possible to perform an on-line phase correction based on the measurements of PWV. Either this, the uncorrected data, or both may be written out by the correlator. The default is to write only the uncorrected data i.e. the WVR correction will be carried out offline.
- **Accumulation Mode**: This is the fundamental averaging time of the correlator chips, after which further averaging is usually performed. There are two choices:
  - FAST – 1 msec (only commissioned for ACA Correlator)
  - NORMAL – 16 msec

  If cross-correlations are desired (together with auto-correlations) NORMAL must be chosen and this is the default. For FAST, only auto-correlation products are produced.
- **LO Offsetting Mode**: LO offsetting is used to suppress signals from unwanted sidebands. Sideband separation of DSB receivers is usually done with 90-degree Walsh switching, but the *rejection* of one sideband is possible using LO offsetting. The main use of LO offsetting is to provide additional suppression of the leakage from one sideband into the other, for 2SB receivers. Offsetting with two LOs uses LO1 and LO2, whilst FDM modes can also offset a third LO, that corresponding to the TFB offset frequency (usually known as LO4). No LO offsetting is used if 90-degree Walsh switching is enabled.
- **Enable 90deg Walsh function**: Allows the sidebands for DSB receivers to be separated in the correlator. Although also technically available to suppress the leakage from the other sideband for 2SB receivers, this will usually be done using LO offsetting.
- **Enable 180deg Walsh function**: This is used to remove spurious signals and DC offsets introduced into the signal path by the ALMA electronics e.g. the digitizer. It is usually enabled.
- **Dump Duration – 64-input Correlator only**: The 64-input Correlator is designed such that the dump interval must be a multiple of 16 ms for the NORMAL accumulation mode. At present, however, multiples of 48 ms (FDM) and 32 ms (TDM) are recommended. Values of around 1 s (e.g. 1.008 s) are usually

selected for interferometric observations, although 2.048 s **must** be used if 90-degree Walsh switching is enabled. For the FAST accumulation mode, the dump duration must be set to 1 ms. A button is available to adjust up to the nearest legal value.

- **Modulation – ACA Correlator only**: If true, perform 180-degree anti-demodulation in the DTS receiver.

- **Demodulation – ACA Correlator only**: This performs 180-degree demodulation in the CIP module. If modulation is chosen, then this must also be set.

6.6.4 BaseBand Configurations

The core of defining an Instrument Setup is the setting of a maximum of 4 basebands (each 2 GHz wide) and the (potentially multiple) spectral windows that sample the baseband signals.

6.6.4.1 Hardware Setup

It is usually the case that the various LOs are set based on the requested baseband frequencies. It is, however, possible to request specific settings of the first local oscillator (LO1) and the First Local Oscillator Offset Generator (FLOOG):

- **Hardware Set-up**: Enable the following options.
  - **FLOOG**: Note that this is sometimes referred to as the first Fine-Tuned Synthesizer. Ticking the "Tune High" box will add this frequency to LO1 (as opposed to subtracting it). The allowed range is 20 to 45 MHz and a value of 32.5 MHz is usually used.
  - **LO1 Frequency**:

Enabling this option also allows certain other parameters to be set per baseband e.g. the use of the 12-GHz filter.

6.6.4.2 LO Setup Preference

- **Sideband(s) to prioritise**: If set, the algorithm will try to place the requested frequencies in the designated sideband. The default is "None" which usually means that USB is prioritised i.e. if all the basebands can fit in a single sideband, this will usually be USB unless the spws frequencies are so low that LSB must be used. All the basebands can be forced into the lower sideband (if they'll fit, obviously) by selecting "LSB". This can be useful to avoid the unused sideband falling into an atmosphereic absorption line. It seems that doing this for one baseband is sufficient.

- **Base band config(s) to prioritise**: Weights (0 to 100) allow the basebands to be prioritised. This could be useful as, due to LO2 not having a continuous range, it is not always possible to tune to the exact frequencies requested. The weights are usually left at the defaults of 100.

- **Doppler Reference**: If the usual route of entering rest frequencies and a source velocity has been followed, this should be set to "rest". However, for high-redshift sources where the desired frequencies have been manually corrected to the lsrk frame, the "lsrk" option should be selected. This will only correct for Earth motion relative to this frame and ignore the source velocity. Finally, if no correction should be made whatsoever, e.g. for pointing and continuum setups, "topo" should be chosen.

- **Calculate LOs 1 and 2**: After the baseband frequencies and the various priorities have been entered, see below, the ability of the system to find a tuning solution should be checked by clicking this button. It is not actually necessary to do this as the telescope control system will calculate the various LOs itself when the SB is run, but it's a very useful check and should in fact always be done.

- **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 data rate summed over all basebands. This is the *output* data rate from the correlator i.e. this number together with the total observing time determines how much data ends up in the ASDM and thus the archive.

6.6.4.3 Basebands

Up to four basebands can be defined and are shown in a tabbed format. A summary table of the basebands is visible above the tabs, into which various properties (most obviously the centre frequencies) of the basebands can be conveniently entered. Some baseband settings are only available via the tabs. 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. The LO2 value cannot be edited unless hardware setup has been selected.

- **Baseband Name**: The four available baseband names must be chosen such that basebands 1 and 2 (or 3 and 4) lie in the same sideband.
- **Desired Centre Frequency**: The *desired* centre frequency for this baseband. How these frequencies are interpreted depends on the value of the Doppler Reference. If this has been set to "rest", then they will be corrected for the source velocity.
- **Actual Centre Frequency (Rest)**: The actual centre frequency (in rest units) for this baseband. Note that this will usually differ from the desired value, albeit only slightly.
- **Actual Centre Frequency (Sky)**: The actual centre frequency in observed units.
- **Products**: Allows the user to select both auto- and cross-correlations or auto-correlations only. When the accumulation mode is FAST, only the auto-correlations can be produced.
- **Use 12 GHz filter**: This selects the 12-GHz low-pass filter that precedes the IF processor – otherwise the 8-GHz filter is used. It is usually required when LO2 exceeds a value of 10.5 GHz. This can only selected if hardware setup has been enabled.
- **Use USB**: The input to the IF processor can, for 2SB receivers, select either the LSB or USB as input. LSB is assumed unless this is checked. A baseband pair (either 1 and 2 or 3 and 4) must use the same setting. This can only selected if hardware setup has been enabled.
- **LO2 Frequency Switching**: Not currently implemented.
  - **Number of Positions**:
  - **Dwell Time**:
- **Polarization mode – ACA Correlator only**: For the ACA Correlator, it is only possible to select the polarization mode of the spectral window per baseband i.e. each spectral window in a baseband *must* produce the same polarization products. It is possible that this is not always the case for the 64-input Correlator.
- **Center Freq of Residual Delay – ACA Correlator only**:
- **Allows ACA Specific Modes – ACA Correlator only**: The ACA Correlator is able to reproduce all the modes that have been defined for the 64-input Correlator. However, it is also capable of producing additional modes and, if this option is checked, it is possible to define these in the spectral window tabs below. Unfortunately, the restrictions on what is allowed in these cases are quite complicated and, although it is attempted to give an idea of these in this document, the ultimate arbiter will be the correlator validator. These modes are generally only required when performing Frequency Profile Synthesis (see below) in the ACA Correlator (not in the ACA_CDP).

6.6.4.4 Spectral Windows

For each baseband it is possible to define multiple spectral windows and these are shown in a tabbed format. A summary table of the spectral windows is visible above the tabs, into which various properties of the spectral windows can be conveniently entered. The full set of options is only available from the tabs.

- **SpectralWindow Name**: Automatically set and non-editable.
- **Centre Offset Frequency**: This is used to set the position of the spectral window within the baseband. Technically speaking, it is equal to the frequency of the astronomical signal after down-conversion by the analogue to digital converter (also known as LO3), plus 2 GHz (don't ask). Using this convention, the available baseband signal covers a range of 2000 to 4000 MHz, and 3000 MHz therefore refers to the baseband's centre. Note that, LSB and USB behave differently – values above 3000 MHz will move the spectral window to higher sky frequencies for USB, but to lower sky frequencies for LSB. As it is not possible to move any part of a spectral window outside of its baseband, the effective range of this parameter is 2000 MHz minus the effective bandwidth. The exact value of the offset frequency is quantised and is equal to 30.517578125 kHz for the 64-input Correlator. The step frequency for the ACA Correlator depends on the bandwidth and number of channels and is calculated as follows:

  ```
  hwSWCh = effectiveBandwidthMHz / (2000.0MHz * 1024 / 2 ** 19)
  swCh = max(hwSWCh, effectiveNumberOfChannels)
  chWidth = effectiveBandwidthMHz / swCh
  step = chWidth * 8
  ```

  To put this into context, for a 62.5 MHz-wide window with 4096 channels (FDM) the step frequency is equal to ∼122 kHz, whilst for 2 GHz and 128 channels (TDM) it is 31.25 MHz. For both correlators a button is available to adjust an approximation to the nearest legal value.
- ***Uncorrected* Centre Offset Frequency**: In determining a tuning solution, the OT calculates the baseband and offset frequencies that are required. However, due to quantisation of LO2, the actual baseband frequencies are often different to those requested. The OT compensates for this, where possible, by **correcting** the offset frequency such that the spectral window is placed as close to the requested central frequency as possible. However, when the SB is run at the telescope and the observations are not being performed in the topocentric frame, the Doppler shift causes the requested spectral window frequencies to be different to those assumed by the OT. The tuning solution will therefore be different, as will the differences between the desired and actual baseband frequencies. This means that the OT's offset frequency corrections are no longer applicable. The OT therefore passes the **uncorrected** centre offset frequencies to the Control system who then re-calculate the necessary corrections in real time. This unfortunately makes it very difficult to change the offset frequency manually unless the spw has a bandwidth of 1875 or 2000 MHz as Control will always use the OT's "corrected" value.
- **Equivalent Omega IF2**: This shows the Centre Offset Frequency using a different definition (non-editable). It is equal to the frequency of the signal immediately after the down-conversion carried out by LO2.
- **Centre Freq(Rest) LSB/USB**: The centre frequency of the spectral window, in rest-frequency units. If sideband separation has been enabled, the value for each sideband will be displayed.
- **Centre Freq(Sky) LSB/USB**:
- **Use LSB**: This tells the correlator to save this sideband's data. If only a single sideband is being produced per spectral window e.g. for SSB and 2SB receivers, then this will be set appropriately and not be editable. For DSB receivers though when the sidebands are being separated i.e. both are produced by the correlator, it is possible to turn one off.
- **Use USB**: As above.

- **Nominal BW / # Channels**: A number of correlator modes have been defined that are common to both the 64-input and ACA Correlators. These can be formed by chosen suitable values for the nominal bandwidth and number of channels from a drop-down menu. If ACA-specific modes have been chosen (see above), this field is not displayed.

- **Effective BW / # Channels**: The displayed values are usually based on the nominal values and not editable. FDM modes produced by the 64-input Correlator have effective bandwidths that are 15/16 that of the nominal, due to overlapping of the digital filters. If ACA-specific modes have been chosen, this field becomes editable and any values can be entered. However, these must still conform to various restrictions and the validator will complain about illegal inputs. The restrictions are somewhat complicated, but essentially every ACA bandwidth is built up from individual chunks with a width equal to the ACA step frequency. For example, whilst 2 GHz and 128 channels is a valid mode, discarding two chunks (each with a bandwidth of 31.25 MHz) results in a bandwidth of 1937.5 GHz and is required when frequency profile synthesis (see below) is performed in the ACA Correlator (a method which is actually now deprecated). As each of these chunks contains two actual correlator channels, the number of channels must also be reduced to 124. In addition, the number of channels must be equal or greater to 16 and the minimum allowed bandwidth is ∼61 kHz.

- **Channel spacing**: This non-editable parameter displays the effective bandwidth divided by the number of channels.

- **CorrConfigMode/Filtermode – 64-input Correlator only**: Correlator configuration internal mode number and filter type (TDM or TFB – the latter is synomynous with FDM).

- **Polarization Products**: Dual polarization (XX and YY) should normally be chosen unless the highest spectral resolution is required, but all four polarization products must be chosen if source polarization is to be determined. These must be the same for all spectral windows within the same baseband. This is not settable for the ACA which has a separate baseband-based polarization field (see above).

- **Averaging Factor**: Specifies the number of spectral channels to average together for each sub-band – this can greatly reduce the data rate when a correlator mode is being used that has much more spectral resolution than actually required. The allowed values are 1, 2, 4, 8 and 16 for the 64-input Correlator and any power of 2 less than the total number of channels for the ACA Correlator.

- **Window Smoothing Function**: Ringing in the output spectrum can be reduced by applying a window function. Hanning is usually applied by default, although other choices are available. Uniform means apply no windowing function.

- **Correlation Bits – 64-input Correlator only**: The number of bits used in the correlation. Higher numbers will increase the sensitivity but will reduce the spectral resolution. Only 2-bit sampling is currently supported. The ACA Correlator always uses 4-bit sampling.

- **Oversampling – 64-input Correlator only**: The input data stream is usually sampled at the Nyquist rate. This can be doubled, slightly increasing the sensitivity, but the spectral resolution will be halved. Oversampling is not currently supported.

- **Quantization Correction – 64-input Correlator only**: This corrects the derived visibilities for inaccuracies due to the limited number of bits used to sample the data. This is also known as the Van Vleck correction.

- **Frequency Ch Profile – ACA Correlator only**: Due to the 64-input and ACA Correlators performing the cross-correlations and Fourier transforms in the opposite order (the former is XF and the latter FX), the spectra of an unresolved spectral line has a different profile in each case (sinc for the 64-input and sinc^2 for the ACA). Selecting this option will trigger an algorithm that converts the ACA spectral profile to that of the 64-input Correlator – this is known as Frequency Profile Synthesis (FPS). If this is selected, the available 2-GHz baseband is shrunk at each edge by the ACA step frequency (defined in Centre Offset Frequency above) and requires that the nominal 2000 MHz-wide mode be replaced by one with a bandwidth of 1937.5 MHz and 124 channels (TDM). However, this way of requesting FPS is now deprecated and has been removed from recent versions of the OT.

- **Synth. Profile – ACA Correlator only**: Frequency Profile Synthesis is now specified via this new parameter. The number of options has increased to three, but the fundamental change is that it is now possible to request that this correction be made in the Correlator Data Processor (CDP), instead of the correlator itself. This will be the default from Cycle 3. If ACA_CDP is selected, the requirement to use ACA-only modes disappears i.e. the full 2000-MHz bandwidth is available.

For each spectral window it is possible to define up to 32 Spectral Average Regions (also known as Channel Average Regions). Note that these parameters are based on the effective channels and are zero-based.

6.7 Observing Parameters

The Observing Parameters node allows the intent of a Target to be defined i.e. science or one of various calibrations. The OT allows more than one to be associated with a single target, but this is not yet supported by the telescope contron software and should not be attempted.

6.7.1 Science Parameters

The Science Parameters have the following items:

- **Science Parameters Name**: This should be a unique and descriptive identifier for the Science Parameters.
- **Representative Bandwidth**: This is the bandwidth that will be used to determine whether the requested sensitivity has been reached. It will usually be the spectral resolution for spectral line observations and the maximum usable bandwidth (7.5 GHz) for continuum.
- **Representative Frequency**: This is the frequency that will be used to determine whether the requested sensitivity has been reached and is read by the ALMA Data Reduction Pipeline for this purpose. It should be in the barycentric frame.
- **Sensitivity Goal**: This is the sensitivity equivalent to that requested by the PI. For the largest 12-m Array or the 7-m Array in the case of SACA, this is simply the value requested by the PI in the Science Goal. For the other arrays, this value is scaled by their relative sensitivity i.e. according to their antenna areas, number of antennas and the time spent observing. For the TP Array, an additional term is added which reflects the noise added by observing a reference position. Currently, the purpose of this parameter is for checking during the QA2 process that the requested sensitivity was met. Note that the sensitivity goal does not reflect any increases in the observing time due to the minimum time spent observing or quantisation issues. Therefore, the sensitivity goal is often worse than that expected in practice. For a sensitivity in kelvins where the PI entered a range of angular resolutions, the sensitivity goal is converted to a flux value using the nominal angular resolution of the largest configuration that is likely to be scheduled. In the future, this parameter might be used to halt an execution once the desired sensitivity is reached i.e. the integration time will be dynamically calculated.
- **Integration Time on source**: Desired integration time for each source attached to this Science Parameters. As dynamic integration times are not yet used, an SB will instead be observed for this amount of time. It normally consists of an integer multiple of subscans, each of which must run to completion. The total on-source time is given by this parameter multiplied by the number of executions. In general, more time than required will be observed due to quantisation effects such as only being able to observe integer multiples of complete mosaics.
- **Sub Scan Duration**: A subscan describes the smallest amount of data that can be continuously observed whilst the telescope is pointing in a specific direction, perhaps with associated scanning movement. This means that changing the telescope pointing (e.g. by changing the scan direction or moving to a new pointing direction) requires a new subscan and thus this parameter sets how long each position in a mosaic, or each scan in a raster, is observed for. If an approximation is entered (the real value often has lots of decimal

places), a button is available to adjust this to the nearest legal value. A value of 30 s is typical. Once begun, a subscan will always run to completion i.e. and integration time of 31 s and a subscan duration of 30 s will produce 60 s of data. All subscan durations must be integer multiples of the integration duration and 48 ms.

- **Force Atmospheric Calibration**: Whether a system temperature measurement is needed will often be determined by the observing script, but checking this will ensure what one is taken every time the science Target is observed.

- **Advanced Parameters**: Not yet implemented.

6.7.2 Calibration Parameters

Many of the calibrator intents share the majority of their parameters. A number of the commonly used calibrators require some additional parameters (e.g. pointing, bandpass) whilst some others, especially observatory modes such as holography and optical pointing, have completely unique sets of parameters.

6.7.2.1 Common Parameters

The parameters that are commonly shared are:

- **Parameters Name**: This should be a unique and descriptive identifier for the Science Parameters.

- **Cycle Time**: How often this calibrator should be observed. Once the time since the beginning of the last scan of this calibration has exceeded the cycle time, a new scan will be scheduled once the current subscan has ended.

- **Default Integration Time**: A nominal time for observing this calibrator. This will in general be exceeded as a subscan (for pointing observations a group of subscans), once started, must be completed. Might one day be overridden by the time taken to achieve some level of calibration accuracy.

- **Data Origin**: Type of data to use for deriving the calibration – the channel average data will often be used.

- **Sub Scan Duration**: This has a similar meaning to that for science observations i.e. the integration time will be made up of one or more subscans and, once a subscan has started, it will be completed. In addition, for calibrations that only make sense with some number n of distinct observations e.g. a five-position pointing, the subscan duration sets how long the telescope points at each position and an integer number of n subscans will always be observed. The subscan duration must be an integer multiple of the integration duration and 48 ms.

- **Force Atmospheric Calibration**: Whether a system temperature measurement is needed will often be determined by the observing script, but checking this will ensure what one is taken every time the science Target is observed.

- **Force Execution**: It is possible that a calibration Target will not actually be observed as the script may decree that it is not necessary e.g. a sufficient calibration exists from a previously executed SB. This can be overridden using this checkbox.

- **Advanced Parameters**: Not yet implemented.

Amplitude, phase, delay and sideband ratio calibrations *only* use the above parameters.

6.7.2.2 Phase-only Parameters

- **Repeat Interval**: This is similar to the cycle time, but attempts a more accurate calculation of the time between successive scans of the phase calibrator. It is calculated as cycle time + phase-calibration integration time + overhead, where the first two terms take into account that an integer number of subscans will be executed e.g. if the subscan duration of the phase calibrator is 60.48 s, this is the minimum amount of time that will be observed and a request of 61 s will result in 120.96 s.

6.7.2.3 Bandpass-only Parameters

- **Desired Phase Accuracy**: Not yet implemented.
- **Maximum Elapsed Time**: Maximum time allowed to achieve the requested accuracy. Not yet implemented.
- **Desired Amplitude Accuracy**: Not yet implemented.

6.7.2.4 Pointing-only Parameters

- **Desired Accuracy**: Not yet implemented.
- **Pointing Method**: Of the various options, FIVE_POINT is always used and probably the only one implemented.
- **Maximum Elapsed Time**: Maximum time allowed to achieve the requested accuracy. Not yet implemented.
- **Excursion**: This should be set to half of the antenna beam size.

6.7.2.5 Focus-only Parameters

- **Axis to adjust**: Specify the axis to focus, i.e. the X, Y or Z axis. The Z-axis is defined by the pointing direction towards the sky and the X and Y axes are perpendicular to this, with the X-axis pointing horizontally towards the right and the Y-axis downwards.

6.7.2.6 Polarization-only Parameters

- **Desired Polarization Accuracy**: Not yet implemented.

6.7.2.7 Atmospheric-only Parameters

Note that these are usually no longer required as the atmospheric calibration is taken care of by the observing script for science observations.

- **Use Hot Load**:
- **Coords Type**:
- **Sky Position**:

6.7.2.8 Optical Pointing-only parameters

The following lists all the Optical Pointing parameters i.e. these do not share any of the common parameters given above.

- **Randomize Order**:
- **Elevation Limit**:
- **Antenna Position Tolerance**:
- **Max Magnitude**:
- **Min Magnitude**:

6.7.2.9 Radiometric Pointing-only parameters

The following lists all the Radiometric Pointing parameters i.e. these do not share any of the common parameters given above.

- **Randomize Order**:
- **Elevation Limit**:
- **Antenna Position Tolerance**:

6.7.2.10 Holography-only Parameters

The following lists all the Holography parameters i.e. these do not share any of the common parameters given above.

- **Tower**:
- **Frequency**:
- **Number of Rows**:
- **Row Size**:
- **Scan Direction**:
- **Speed**:
- **Start Fraction**:
- **Calibration Mode**:
- **Calibration Time**:
- **Calibration Rows**:
- **uniDirectionalScan**:

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. An example of the image display can be seen in Figure 7.1.

One feature of the Visual Editor is that it will convert between ICRS and Galactic coordinates in the event that the displayed image and the coordinates defined in the Forms editor use different systems. Therefore, individual pointings defined in ICRS will be shown at the correct position on a Galactic image and, if the pointings are defined or shifted on the image, the ICRS coordinates in the Forms editor will be appropriately updated. In a similar way, a rectangle will be rotated to take into account the angle between the two coordinate systems at the source position.

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. FITS extensions are supported, but only the first one can be read. From Cycle 6, images in Galactic coordinates are 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**: Use the cursor to define an individual pointing. Individual pointings are drawn in red to indicate the antenna beamsize (field of view) and surround a green, dashed circle that indicates the inner third of the beamsize - beyond this the sensitivity will be significantly lower than requested.
- **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 will be automatically turned into a mosaic for use by the 12-m Array and possibly the ACA 7-m Array. A larger turquoise rectangle represents the area that will be observed using the ACA TP Array (if necessary and available).
- **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.

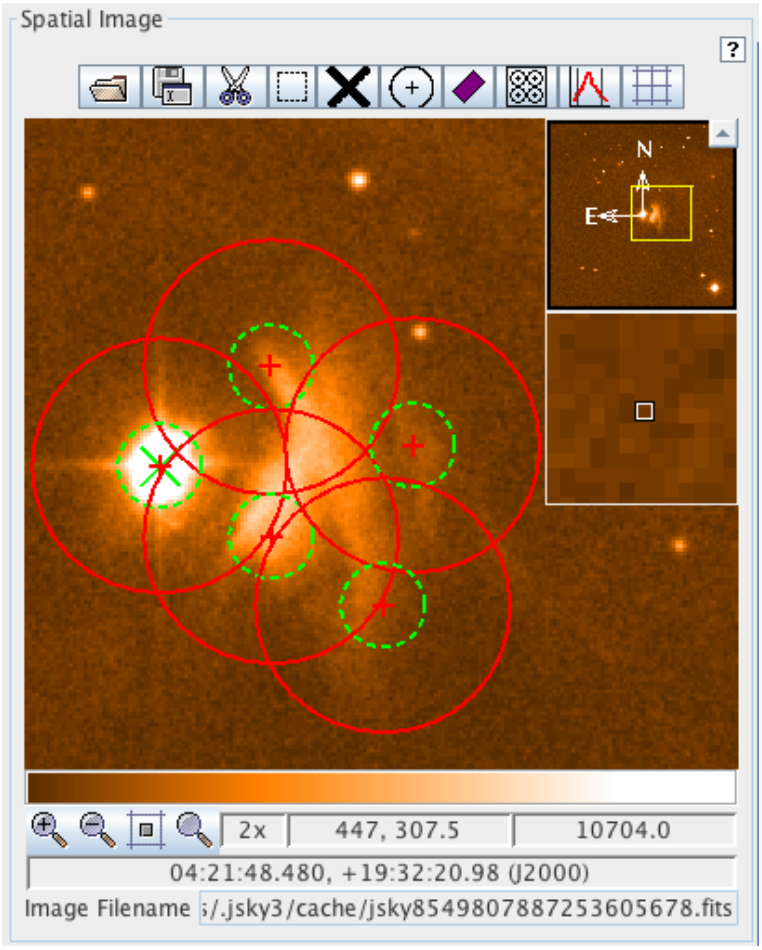

Figure 7.1: An example of the image display area of the Visual Spatial Editor. This is for a set of individual pointings and shows the antenna beamsize (field of view) of the individual pointings (in red). The green, dashed circles indicate the inner third of the field of view. This is to emphasise to the user that the sensitivity drops off away from the pointing centre.

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

At the bottom of the display, dragging the mouse within the colourbar will change the displayed contrast – right-clicking in the same area will reset the display to the default contrast. Below this, 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

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.
- **Array Type**: If both the 12- and 7-m configurations are required, this button will determine which array's pointings are displayed.
- **Antenna Beamsize (FWHM)**: Display a red circle marking the FWHM of the antenna primary beam. A smaller green circle shows the inner third.

- **Show Antenna Beamsize (circle)**: Tick to display the chosen antenna beamsize and 1/3 of the beamsize markers.

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.

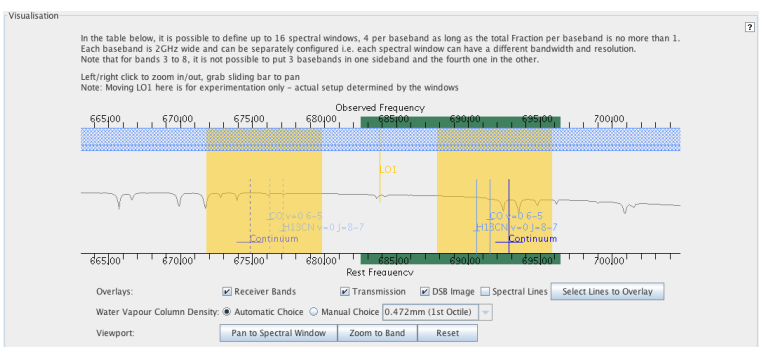

Figure 7.2: The graphical representation of the frequency information for Science Goals. The yellow sidebands indicate that a valid tuning solution has been found – these would otherwise appear grey. The green bars can be grabbed by the mouse and used to drag the display.

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.

  - **DSB Image**: For DSB receivers (bands 9 and 10) this displays the "image" counterpart of each spectral window. The image spectral window lies in the other sideband (equidistant from the LO1 frequency) and will show sources of contamination or excess noise e.g. other lines and atmospheric absorption, that will also affect the requested spectral window.
  - **Spectral Lines**: Display lines selected with the Spectral Line Picker.
  - **Select Lines to Overlay**: Choose lines to overlay using the Spectral Line Picker.

- **Spectral Scan**
  - **Requested scan**: Show the range over which the spectral scan was supposed to cover. This will rarely exactly correspond to what was achieveable in practice.
  - **Tuning 1, 2, etc.**: Display the spectral windows corresponding to a specific tuning. Each tuning is coloured differently and is offset vertically.

- **Water Vapour Column Density**
  - **Automatic Choice**: Allow the OT to automatically select the appropriate value of PWV according to the Representative Frequency and draw the corresponding transmission plot. This is recommended.
  - **Manual Choice**: Override the OT's choice. This is for experimentation only – the OT will ignore this when calculating the time required for a Science Goal.

- **Viewport**
  - **Pan To Spectral Window**: This will centre the visualiser on the currently selected spectral window.
  - **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 6.6.1.

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. It's not clear that the drawing of these can be turned off.
- **Overlay Lines**: Show lines that have been selected using the Spectral Line Picker (see below).
- **BBC Centre Frequencies**: Display the centre frequencies of the baseband configurations.
- **Receiver Bands**: Display the frequency ranges of all receiver bands, not just the one selected.
- **Sidebands**: Display the LSB and USB ranges.
- **Transmission**: Display the atmospheric transmission curve.
- **Select Lines to Overlay**: Click to start the Spectral Line Picker and select lines to be displayed.
- **Pan To Representative**: Pan to the representative frequency.
- **Zoom To Band**: Zoom to the current receiver band.

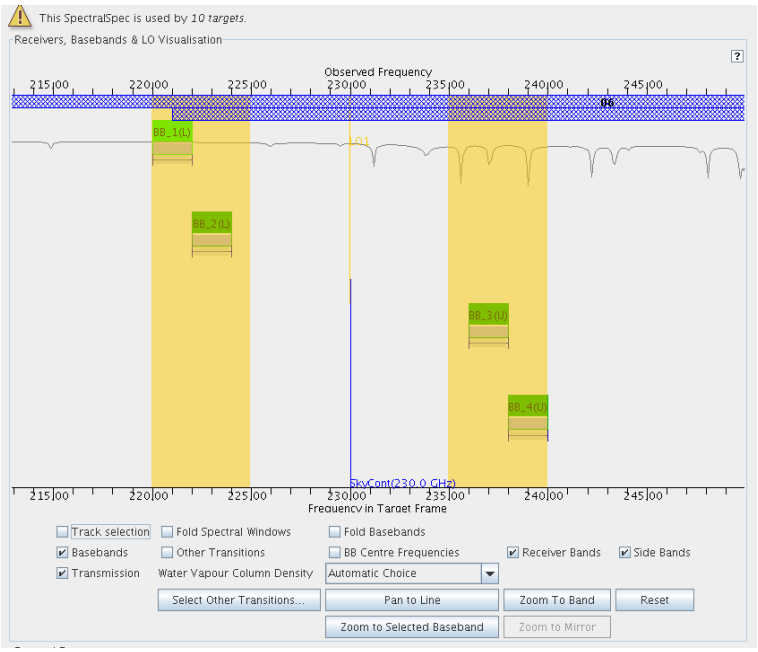

Figure 7.3: Visualisation of frequency information about receivers, basebands and LO frequencies. Visible are part of the frequency band (hashed), the transmission curve, four basebands and their spectral windows. This is the version shown in the SB.

- **Reset**: Reset the display settings.
- **Zoom to Selected Baseband**: Zoom to the selected baseband.
- **Zoom to Mirror**: Centre on the mirror of the currently selected baseband. Only relevant in Bands 9 and 10. This button is badly named as there is no actual zooming.

This page was intentionally left almost blank

Chapter 8

Acronym List

2SB: Two Sideband (receiver)
ACA: Atacama Compact Array
ALMA: Atacama Large Millimeter/submillimeter Array
APDM: ALMA Project Data Model
ASA: ALMA Science Archive
ASDM: ALMA Science Data Model
ARC: ALMA Regional Centre
ASC: ALMA Sensitivity Calculator
BBC: Baseband Converter
DGC: Differential Gain Calibration
DDT: Director's Discretionary Time
DSB: Double Sideband (receiver)
EB: Execution Block
FOV: Field Of View
GOUS: Group Observing Unit Set
LAS: Largest Angular Scale
LO: Local Oscillator
LSB: Lower Side Band
MOUS: Member Observing Unit Set
MRS: Maximum Recoverable Scale
OG: Observing Group
OT: Observing Tool
OTF: On The Fly
OUS: Observing Unit Set
PI: Principal Investigator
PWV: Precipitable Water Vapour
QA2: Quality Assurance (second level thereof)
SACA: Stand-alone ACA
SB: Scheduling Block
SG: Science Goal
SSB: Single Sideband (receiver)
SFI: Single Field Interferometry
SLP: Spectral Line Picker
SPW: Spectral Window
TFB: Tunable Filter Bank
TP: Total Power
USB: Upper Side Band

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of the European Organisation 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 and Technology Council (NSTC) in Taiwan 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.