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SearchCal 5.0 - User Manual

Authors:
Laurent Bourgès (LBo) <laurent.bourges@univ-grenoble-alpes.fr> — OSUG
Gilles Duvert (GDu) <gilles.duvert@univ-grenoble-alpes.fr> — IPAG

Author: JMMC Calibrator Group Institute: IPAG / OSUG	Signature: Date: 27 June 2017
Approved by: Institute:	Signature: Date:
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1 Introduction

1.1 Abbreviations and acronyms

JMMC	Jean-Marie Mariotti Center
SearchCal	The Search Calibrators tool
JSDC	JMMC Stellar Diameters Catalogue
CDS	Centre de Donnees Astronomiques de Strasbourg
IVOA	International Virtual Observatory Alliance

1.2 Presentation

Few software tools are available to help the astronomer find good calibrators for optical interferometry observations. `SearchCal` is both a server-side software that dynamically builds a catalog of stars with all useful information for the selection of the calibrators used in optical interferometry, and a client-side tool to select a subset of this catalog for particular observing purposes. This tool is not restricted to a particular spectral band, and can be used from the visible (V band) to the mid-infrared (N band). The strategy for the selection of potential interferometric calibrator is based on the gathering of a large set of information from the VizieR astronomical catalogs & SIMBAD querying services hosted at CDS. Those data are primarily used to determine several angular diameter estimates of the sources. Based on some criteria concerning the visibility of the sources for a given wavelength and projected baseline, and also the consistency of the diameter estimates, the user can then decide whether each proposed star can be considered as a good calibrator or not. `SearchCal` also provides some insights to help detect multiple, variable or complex sources.

The software has been completely rewritten in 2015-2016 following the new approach described in a paper by Chelli et al., see http://simbad.u-strasbg.fr/simbad/sim-ref?bibcode=2016A\&A...589A.112C. This new approach permits not only a much larger amount of candidate calibrator sources (up to 2.5 million), but also an improvement in accuracy for the estimated diameters. The present documentation has been thus completely rewritten.

1.3 Disclaimer

We warn the user that the sources provided by `SearchCal` do not come from observing program dedicated catalogs, and therefore are NOT fully guaranteed. `SearchCal` proposes a selection of sources with the highest possible probability to be good calibrators, but this do not prevent the user from an inspection of the literature concerning the sources resulting from the search. In particular, it is notorious that the fraction of sources with detected companions increases at fast rate, implying that the catalogs consulted are not necessarily up to date in this regard at the time of query. Finally, we remind that the method employed is statistical, i.e. a few individual stars may have a quite different diameter than expected ($3\sigma \simeq 97\%$).

1.4 Installation

Availability `SearchCal` is freely available for download on the JMMC website at http://www.jmmc.fr/searchcal.

Requirements `SearchCal` is based on Java 6 or greater, so your computer must have it installed (see http://www.jmmc.fr/apps.htm for more details). An Internet connection is only required to get calibrators from `SearchCal` servers at JMMC.

1.5 Acknowledgments

As with all other JMMC software, you shall acknowledge `SearchCal` usage if it was of any help in your research. See section 3.6 for more details.

SearchCal itself is based on multiple Open Source libraries and public services. We would like to thank:

- CDS, especially for their great VizieR and SIMBAD services without which SearchCal wouldn't have been possible, and their SAVOT VOTable parser which is at the core of SearchCal graphical interface;
- Mark Taylor of Bristol University in England, for its huge commitment to ease astronomers everyday life with such great tools as TOPCAT and STILTS, or its essential jSAMP library enabling easy yet reliable inter-application data exchanges;
- JMCS, the core JMMC graphical interface library, providing lots of missing stuff in Java, either developed internally or by incorporating third-party libraries, to help our end-users feel right at home using our apps.

1.6 Method

The method is described in a paper by Chelli et al., see http://simbad.u-strasbg.fr/simbad/sim-ref?bibcode=2016A\&A...589A.112C. This method permits to estimate with a precision of a few milliarcsecs (mas) the Limb-Darkened (angular) Diameter (LDD) of a star when its V,J,H,K photometry and spectral type are known. This leads to produce a catalog of 450 000 angular diameters, the JSDC version 2 hosted at CDS (http://cdsarc.u-strasbg.fr/viz-bin/Cat?II/346).

The SearchCal client interface is able to browse in this catalog, which is selected using the **BRIGHT** search mode, and in an additional "myopic" catalog of $\sim 2\,000\,000$ other fainter stars where the SearchCal server has "guessed" the spectral type, available using the **FAINT** search mode.

Both the JSDC catalog and the SearchCal client show additional information, such as Uniform Diameters (UDD). The conversion from LDD to UDD in each spectral band is made using mainly the coefficients from http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=J/A%2bA/556/A86/table16 and http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=J/A%2bA/554/A98/table16 when possible (compatible spectral types) and following the prescriptions of the JMMC report at http://www.mariotti.fr/doc/approved/JMMC-MEM-2610-0001.pdf in all other cases. The errors on UDD values are omitted as they are similar to the estimated LDD error.

The SearchCal client displays results matching the request by selecting the targets in the BRIGHT catalog or the FAINT extension according to the search criteria, namely the maximum distance from the science target, within the magnitude range and observing band. Many filters, some selected by default depending on the observing band, are available to sort among the (now quite large) number of calibrator candidates.

For each star, the squared visibility (V^2_{cal}, ΔV^2_{cal}) is dynamically computed as function of the angular diameter (UD), current wavelength and maximum baseline defined in the SearchCal client.

1.6.1 Further selecting calibrators

It is possible, once the list of potential calibrators has been retrieved, to refine the choice of the calibrators using several selection criteria:

- field size around the science object
- calibrator maximum magnitude
- spectral type and luminosity class
- minimum value of the visibility
- accuracy on the visibility
- information regarding the potential calibrator variability and multiplicity (e.g., to avoid close, or spectroscopic, binaries)

- suspicious object type (SIMBAD)
- diameter estimation quality (maximum dispersion or relative error)

2 How to use SearchCal

In Fig. 1 the main window of the `SearchCal` client is shown. This window consists in three sections from top to bottom, the `Query Parameters` panel, the `Found Calibrators` panel showing the result of the query and the `Filters` panel enabling a refinement of the calibrator selection based on various filters and parameters.

2.1 Query setup

The `Query Parameters` panel shows three sub-sections from left to right:

The `Instrumental Configuration` section first allows one to select the observing `Magnitude Band` and the `Wavelength` (by default the standard wavelength of the photometric band). The `Max. Baseline` length of the observing baseline must also be provided. The `Wavelength` and `Max. Baseline` parameters are used only by the `SearchCal` client interface to dynamically compute the square visibility, so you can adjust the baseline length and see its impact on calibrator candidates.

The `Science Object` section shows the parameters describing the star you want to observe. Its position (RA, DEC) and magnitude for the selected photometric band (which are mandatory for the request) can be either manually entered, or automatically retrieved over the Internet using the 'rounded-corner' search field. Simply enter its name or any identifier (the syntax must follow the rules used for Simbad) to get those values from the Simbad service hosted at CDS.

The `SearchCal Parameters` section allows one to specify the magnitude range in the selected photometric band, and the sky field in which the calibrators will be searched. The user selects the search algorithm among `Bright` and `Faint` modes:

- In the `Bright` case (few, on average brighter, stars with known spectral type) the research field is a rectangular box, with a maximum size of 240.0 min (60°) in Right Ascension and 30.0° in Declination.
- In the `Faint` case (all 2.5 million stars) the research field needed is just a small circular patch of typically a dozen arc minutes, with a maximum radius of 3600 arcmin (60°).

2.2 Results browsing

Once the user filled the `Query Parameters` panel, the request is sent by clicking the `Get Calibrators` button or menu.

The `Found Calibrators` panel shows the list of the calibrators with default filters applied (checked boxes in the filter list). A minimalist set of columns is shown by default to better summarize calibrator characteristics. But the user can also choose to see a more detailed view for each calibrator by opening the `Calibrators` menu and selecting `Result Verbosity : detailed`. But there is even more data available by using the `Full` verbosity for advanced users.

The default order of each column sets can be changed using the `Preferences` window. By clicking and dragging any column header, it is also possible to temporarily personalize their order. Moreover, by clicking on column headers, the result table is sorted out following the increasing value of the parameter. A second click on the column header reverse the sorting order to decreasing mode.

Please note that the first (when ordered by distance) row may appear in bold face if it contains the science object (i.e its distance is less than 1 mas). This only happens if the science object is also a potential calibrator, so `SearchCal` was able to harvest data about it.

By using the `Show Legend` menu item in the `Calibrators` menu, the `Legend` sub-panel opens on the right side of the `Found Calibrators` panel. The various colors identify the origin of each cell value. The

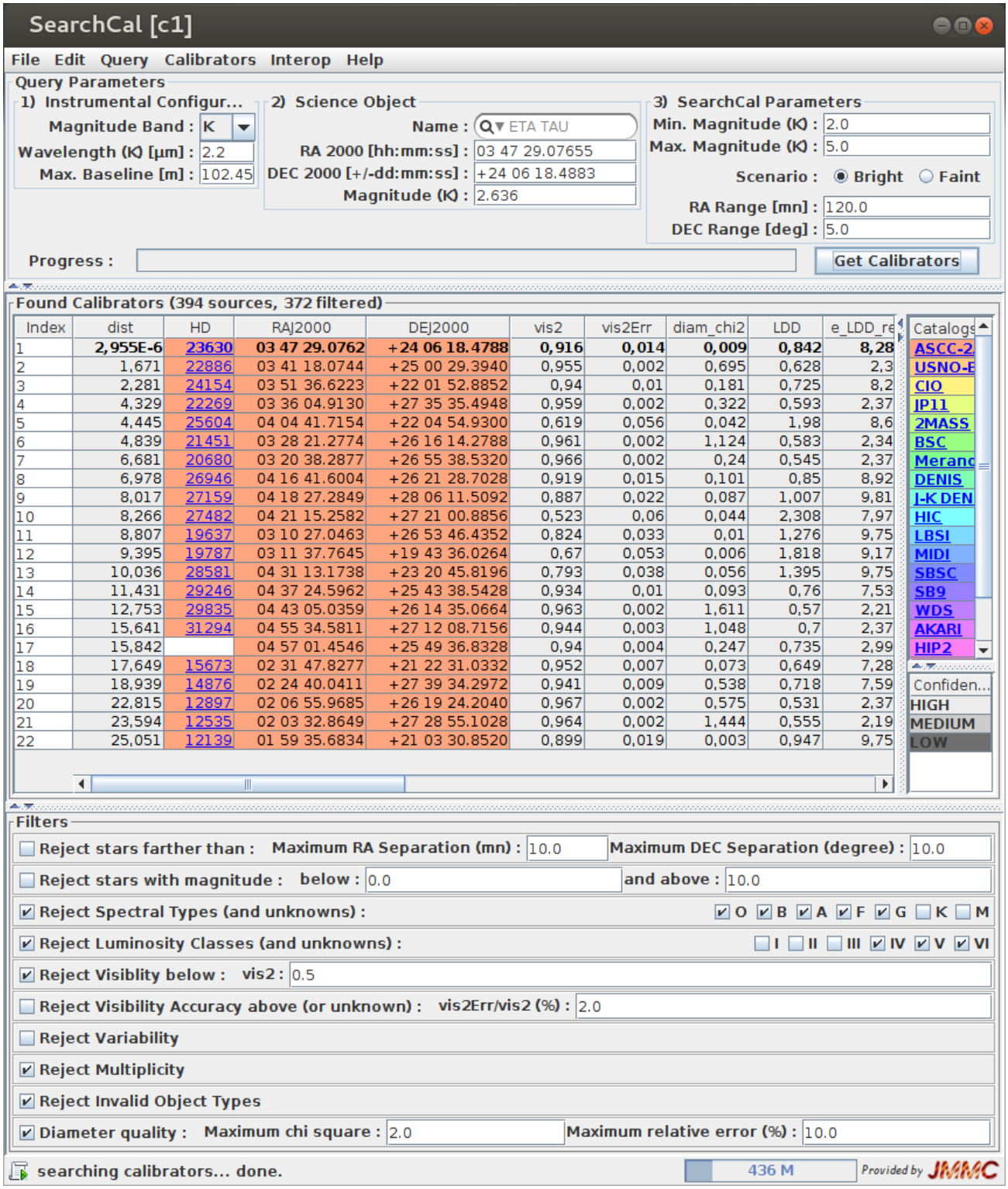

Figure 1: Main Window

description of each catalog is directly available in the Vizier service at CDS by clicking their name. The lower part of the `Legend` sub-panel contains a color description indicative of the confidence of computed values: `LOW`, `MEDIUM` or `HIGH`.

For each calibrator found, the user can easily go to the corresponding Vizier entry at CDS by clicking on any calibrator identifier shown in the `HD`, `HIP` or `2MASS` columns.

2.3 Further filtering

The `Filters` panel allows the user to dynamically refine the list of calibrators, without any loss of data nor further query to CDS. Each filter is individually enabled or disabled using its left-most checkbox. Here is the list of selection criterion applicable on the current result set, from top to bottom:

- The first criterion rejects sources farther from the Science Object than the indicated maximum R.A. and DEC values.
- Then follows a criterion based on the magnitude to define the faintest calibrator allowed.
- The following criteria defines the spectral types and luminosity classes to reject.
- The next criterion sets the minimum squared visibility allowed. This is a key criterion to select interferometric calibrators at a given baseline, since good calibrators are expected to have squared visibilities as close as possible to 1.0.
- Similarly, follows a criterion to set the maximum estimated error on the squared visibility allowed. This criterion is an indirect information on the quality of the calibrator. Please note however that such an estimate is difficult to evaluate, and this criterion should be used with caution.
- The variability criterion works on data collected from the I/280 (All-sky Compiled Catalogue, Kharchenko 2001) catalogue. If any of the variability flag columns means variability suspicion, the source is rejected.
- The next criterion is all about sources multiplicity. It rejects stars known as either a spectroscopic binary in the SBC9 catalogue (Pourbaix et al., 2004), or as a visual binary in the WDS catalogue (Mason et al., 2001) where sep1 <2" or sep2 <2".
- The next criterion uses SIMBAD object types to reject "invalid" sources (Algol, Mira, rapid rotators ...& candidates) that should not be considered as good calibrators.
- The final criterion operates on the diameter estimation quality to define the upper limit on either the diameter dispersion (chi square) or the relative error of the mean diameter (LDD).

2.4 Examples

On first launch, `SearchCal` loads with default querying parameters. You can simply press the `Get Calibrators` button to start a first demonstration query. In the following section, we provide you with more example of usage if needed.

2.4.1 Bright Query

Here is a set of parameters to input in the `Query Parameters` panel to do your first bright calibrator research:

- `Magnitude Band` : select "K" in the popup menu;
- `Wavelength` : type "2.2" (without quotes);
- `Max. Baseline` : type "102.45" (without quotes);

- `Name` : type "Alpha Cen" (without quotes), then enter to automatically fulfill coordinates and magnitudes;
- `Min. Magnitude` : type "-1" (without quotes);
- `Max. Magnitude` : type "4" (without quotes);
- `Scenario` : click on the "Bright" radio button;
- `RA Range` : type "60" (without quotes);
- `DEC Range` : type "10" (without quotes);

All mandatory parameters are now defined. Then click on the `Get Calibrators` button to launch the search. After a while (the progress bar gives you the status of the currently running query), your results appear in the `Found Calibrators` pane. You can now filter your results using the `Filters` panel, by:

- `Luminosity Classes` : enable this filter (by clicking on its left-most checkbox), then click on the "V" checkbox to hide calibrators belonging to the "V" luminosity class group;
- `Spectral Types` : enable this filter (by clicking on its left-most checkbox), then click on the "G" checkbox to hide calibrators belonging to the "G" spectral type group.

2.4.2 Faint Query

Here is a set of parameters to input in the `Query Parameters` panel to do your first faint calibrator research:

- `Magnitude Band` : select "K" in the popup menu;
- `Wavelength` : type "2.2" (without quotes);
- `Max. Baseline` : type "102.45" (without quotes);
- `Name` : type "Tau Boo" (without quotes), then enter to automatically fulfill coordinates and magnitudes;
- `Min. Magnitude` : type "4" (without quotes);
- `Max. Magnitude` : type "8" (without quotes);
- `Scenario` : click on the "Faint" radio button;
- `Radius` : type "60.0" (without quotes);

All mandatory parameters are now defined. Then click on the `Get Calibrators` button to launch the search. After a while (the progress bar gives you the status of the currently running query), your results appear in the `Found Calibrators` panel. You can now filter these results using the `Filters` pane, by:

- `Magnitudes` : enable this filter (by clicking on its left-most checkbox), then type "7" (without quotes) to hide calibrators whose magnitude is greater than 7;
- `Multiplicity` : disable this filter (by clicking on its left-most checkbox), to show calibrators potentially composed of multiple sources (as spectral binaries, ...).

3 Menu Bar walkthrough

`SearchCal` top main menu bar contains the following entries:

`File` : to open and save the results of your queries.

`Edit` : to cut and paste, find any value and change the preferences of `SearchCal`.

`Query` : to reset or change the default values of the query panel.

`Calibrators` : to determine the level of details of the calibrators panel.

`Interop` : to share `SearchCal` results with other VO-compliant applications like `ASPRO2` or `Aladin`.

`Help` : contains the information about `SearchCal`, plus means to communicate with us.

3.1 File menu

The `File` menu provides the user with the ability to load, save, print, and export its calibrator list. `SearchCal` native file format is VOTable-compliant. IVOA described VOTable format as an XML standard for the interchange of data represented as a set of tables. VOTable is a flexible storage and exchange format for tabular data, with particular emphasis on astronomical tables. This file format advantage is its interoperability with (i.e its ability to be opened by) lots of VO-compliant tools, like TOPCAT, Aladin, ... `SearchCal` VOTable file type is *.scvot. Any VO-compliant software can open `SearchCal` files. On the other hand, as `SearchCal` stores lots more than raw values in its files, it only understands its very own *.scvot VOTables, but does not support opening of general purpose VOTables.

The `Open` menu loads calibrator lists previously saved by `SearchCal` in the *.scvot VOTable file format.

The `Save` and `Save As...` menus can save fetched calibrator lists in the VOTable-compliant *.scvot `SearchCal` file format.

The `Revert to Saved` menu reloads the current calibrator list in its previously saved state, thus losing any modification made in between.

The `Export to CSV...` menu writes the current calibrator list in “comma-separated values” file format, compatible for example with OpenOffice (or any other modern data analysis application).

The `Export to HTML...` menu writes the current calibrator list in HTML, for Web publication or presentation.

3.2 Edit menu

The `Edit` menu is mostly standard, providing you with widely expected copy-pasting and deletion functionalities. It also features find capabilities, to search specific values within the calibrator list.

The `Find` sub-menu offers standard search functions, such as defining the desired token (either in simple or regexp format) in the Find window with `Find...`, jumping to the next token occurrence with `Find Next`, or going backward with `Find Previous`.

The `Delete` menu item allows you to hide currently selected calibrators from result list.

The `Undelete` menu restore all previously deleted calibrators.

The `Preferences...` menu shows you the application setting window as expected.

3.3 Query menu

The `Query` menu provides options dealing with `Query Parameters` panel.

The `Reset Values` menu blanks all `Query Parameters` panel fields.

The `Load Default Values` menu restores all parameters to their previously saved states (or factory defaults if none).

The `Save Values as Default` menu puts all current parameters values as preferences, so as to be automatically retrieved each time you launch `SearchCal`.

3.4 Calibrators menu

The `Calibrators` menu deals with `Found Calibrators` panel configuration.

The `Results Verbosity` sub-menu offers several levels of detail among `Synthetic`, `Detailed` and `Full`. Each of those levels corresponds to a different extended set of columns according to the instrument band and the Bright / Faint search mode, providing you with more information for each calibrator in the list.

The `Show Legend` menu shows a dedicated panel on the right of the calibrator list, explaining you the meaning of colors used in each list cells.

The `Get Calibrators` menu launches the query to populate the result list.

3.5 Interop menu

The `Interop` menu allows to share `SearchCal` calibrator list (or selection) with other VO-compatible tools through SAMP (see http://www.ivoa.net/cgi-bin/twiki/bin/view/IVOA/SampSoftware for the official list). SAMP relies on a hub-based architecture, to which every compatible software register, in order to facilitate inter-process communication and discovery.

The `(Un)register Hub` menu can be used to (dis)connect `SearchCal` to/from SAMP hub. If no hub found, `SearchCal` will start one automatically.

The `Show Hub Status` displays SAMP hub control window, mainly for debugging purpose.

The `Send Calibrators to` menu sends current calibrator list or sub-selection to other VO tools (only available if compatible software able to handle VOTable is registered to the SAMP hub, e.g ASPRO2, Aladin, TOPCAT, or any other tool able to open VOTables through SAMP).

3.6 Help menu

The `Help` menu is an important tool to get information about our software, but also to communicate with us.

The `User Manual` menu allows you to browse `SearchCal` user documentation right from within the application. You can hierarchically browse the manual, or search through it.

The `Report Feedback to JMMC...` menu allows you to provide us with any comment, enhancement request or encountered problem. Please, carefully select the type of comment, as they are addressed to different persons across our teams. The user mail is an OPTIONAL entry, but is needed if you expect any feedback from us regarding your remark. If you fill it once, it will be remembered later on.

The `Copy Acknowledgment to Clipboard` menu puts the `SearchCal` acknowledgment sentence and Bibtex entry in your pasteboard, so you can easily paste it into the reference list of your papers that made use of `SearchCal` in any means.

The `Hot News (RSS Feed)` menu opens your default Web browser on a page listing all events concerning `SearchCal`.

The `Release Notes` menu opens your default Web browser on a page reporting the last releases and changes of `SearchCal`.

The `Frequently Asked Questions` menu opens your default Web browser on the `SearchCal` FAQ web page.

4 Preferences Window functionalities

The window panes shown in Fig. 2 allow you to customize the default behaviour of `SearchCal` to better fit your needs. Any change you do is for the current run of `SearchCal` only, until you press the `Save Modification` button. This will write your current configuration settings to file, in order to be restored later when you launch `SearchCal`. You can of course revert to factory settings at any moment, using the `Restore Default Settings` button. But be warned that this will definitively erase any previous configuration done, including your default query parameters values (if any).

4.1 Columns Order setup

This panel allows you to change the default columns order for each possible configuration (bright/faint, magnitude band). By selecting the desired configuration, then selecting the column to move, you can change its position using the `Up` and `Down` buttons, and dynamically watch the modification in your current calibrator list (if the same view is currently shown).

4.2 Legend Colors customization

This panel allows you to change the colors used to show you the origin and confidence of the data in the calibrator list. By clicking each row, you can then choose a new color as desired, and dynamically watch the modification in your current calibrator list as well.

4.3 Help Settings definition

This panel allows you to define our various help functions default behaviours.

The `Results Verbosity` radio buttons set the desired detail level used to display `SearchCal` calibrator results by default, among `Synthetic`, `Detailed` and `Full`.

The `Show Legend` enables or disables the default display of the legend view.

The `Show Tooltips` enables or disables the contextual help balloons shown while approaching your mouse pointer to some widgets (as calibrator list cells, buttons, ...).

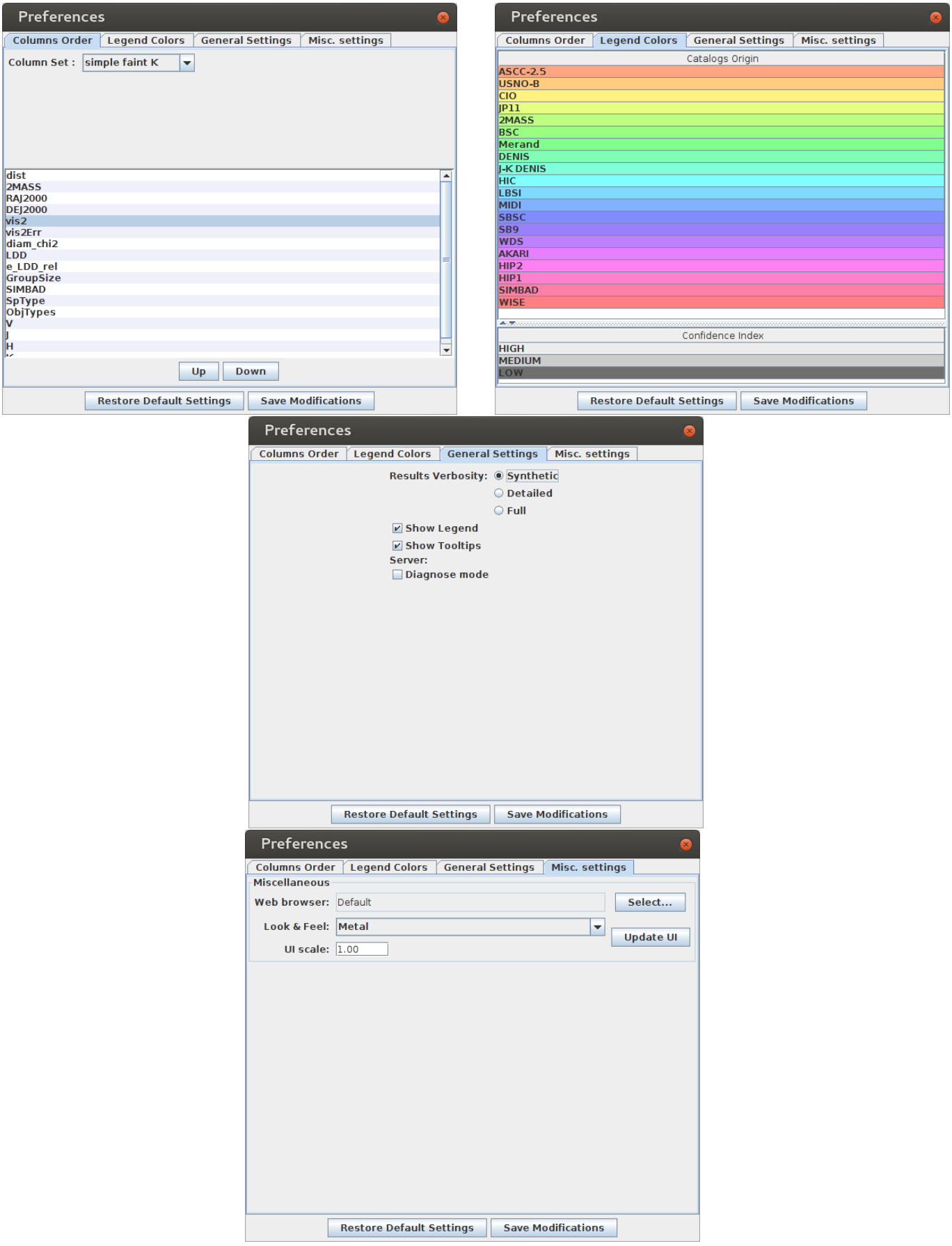

Figure 2: Preferences Window Panes