ASTRO

A GILDAS software

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Questions? Comments? Bug reports? Mail to: `gildas@iram.fr`

The GILDAS team welcomes an acknowledgment in publications
using GILDAS software to reduce and/or analyze data.
Please use the following reference in your publications:
`http://www.iram.fr/IRAMFR/GILDAS`

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1. IRAM
2. Observatoire de Paris

Related information is available from:

- CLIC: Continuum and Line Interferometric Calibration
- CLASS: Continuum and Line Analysis Single-dish Software
- GREG: Graphical Possibilities
- SIC: Command Line Interpreter
- IRAM Plateau de Bure Interferometer: Flux Measurements

Contents

Chapter 1

Introduction

This document gives a description of the ASTRO software, developed to help astronomers to prepare their observations with the IRAM telescopes. ASTRO stands for "A Software To pRepare Observations".

ASTRO includes a series of tools to compute **ephemeris**, typically the position of sources as seen at a given time from a given location. These commands are described in Chapter 2. Although they are slighlty biased towards (sub)millimeter astronomy, specially in the terminology used for input and output parameters, these commands are generic enough to be used to plan observations with any instrument.

A number of tools are available to **prepare millimeter-wave observations** (Chapter 3). Especially, ASTRO provides an interface to the `ATM` library, that can be used to model the atmospheric absorption and emission at millimeter wavelengths.

ASTRO also includes a number of tools that are **specific to the IRAM instruments**, and are aimed at helping astronomers to prepare observing procedures for the Pico Veleta 30m antenna and the NOEMA interferometer. These tools are descrived in Chapters 4 and 5.

Chapter 2

Ephemeris

2.1 Setting observatory and time

2.1.1 Setting the observatory

The results of most commands of ASTRO depend on the observer's location on Earth. This information is input to the software using the OBSERVATORY command:

```
OBSERVATORY longitude latitude altitude [sunlimit]
```

where the longitude and latitude are in degrees (with the usual convention of positive values towards North and East respectively) and the altitude is in kilometers. The fourth parameter is the radius of the sun avoidance circle (default is 30 degrees), used to indicate in plots the sky area that cannot be observed. A number of observatories are pre-defined and can be selected directly by typing:

```
OBSERVATORY name
```

Known observatories are given in Table 2.1. Note, that the Plateau de Bure sun avoidance limit used to be 45 degrees, but has been decreased to 35 degrees in July 2009. For the submillimeter and millimeter facilities within this list, ASTRO also assumes an antenna diameter, that is used to compute the beam size and thereby the main beam brightness temperatures of planets (see PLANET command).

When entering only OBSERVATORY (without argument), ASTRO will select the default observatory. The latter is defined by the GAG_ASTRO_OBS logical:

```
SIC LOG GAG_ASTRO_OBS PICO      ! define PICO as default observatory
OBSERVATORY ALMA                ! select ALMA as observatory
OBSERVATORY                     ! select PICO as observatory
```

For IRAM instruments and ALMA, the observatory selection activates commands to prepare receiver and correlator setups (see related chapters). In this frame, the commands OBSERVATORY NOEMA and OBSERVATORY PDBI (or BURE) select the same position on Earth, sun limit and dish diameter, but different commands to represent the different hardware status (PDBI/BURE = up to 2017, NOEMA = as of 2017).

Note that some commands take into account different versions of the hardware. They are accessible by adding an argument after the observatory name. For PDBI and NOEMA, versions are identified through years. For ALMA, versions are identified by cycle number.

Note for experts – The logical `GAG_ASTRO_OBS` is defined in the `gag.dico.gbl` file in the GILDAS distribution. By default, it is set to BURE. To override this default, users have to "export GAG_OBSERVATORY=ObservatoryName" just before sourcing gildas-env.sh at the beginning of the compilation procedure. Another possibility to permanently modify the value of `GAG_ASTRO_OBS` is to edit the `astro-site.astro` procedure (see section 2.1.3).

2.1.2 Setting the time

Atfter having set the observatory, it is necessary to define the time at which ephemeris must be calculated, using the command:

```
TIME hour date
```

Formats are "hh:mm:ss.ss" and "jj-mmm-yyyy". Entering only `TIME` will use the current system time and date. By default, time and date are supposed to be in UTC (Universal Time Coordinated). However, time may also be entered in:

- local time, using the option `/ZONE z` where `z` is the number of hours to be substracted to the local time to convert it to UTC (example: `/ZONE 2` corresponds to Summer Time in Western Europe).
- UT1, using the option `/UT1`. The difference between UTC and UT1 can be modifed using the `SET DUT1 dUT1_value` command. As of January 2008, dUT1 is -0.3 sec (Bulletin D 98 of IERS). By construction of UTC, the value of dUT1 is always lower than 1 sec. The difference is therefore very small for all usual ephemeris computations.
- TDT (Terrestrial Dynamical Time), using the option `/TDT`. The difference between UTC and TDT can be modifed using the `SET DTDT dTDT_value` command. Since January 2006, dTDT1 is 65.184 sec (last introduction of a leap second, Bulletin C 30 of IERS).

Definitions – The definition of the various times used in astronomy is given in a number of excellent textbooks. To make a quite complex story short: time standard is the TAI (International Atomic Time), which is not defined by an astronomical measurement. The TDT (Terrestrial Dynamic Time) is defined as TDT=TAI+32.1284, the offset being introduced to allow for a continuity with older definitions. UT1 is defined by astronomical measurements of the Earth rotation, corrected for various effects. UT1 differs from TAI, because of the irregularity of the Earth rotation period at the millisecond level, and drifts slowly with time, because of the overall slowing down of the Earth rotation. UTC is defined as TAI + a certain offset, such that $|\mathrm{UTC}-\mathrm{UT1}| < 1$ sec, i.e. UTC is an atomic-based time that is tracking the astronomical-based time within one second. Since UT1 drifts compared to TAI (and thus UTC), a leap second in UTC may be introduced on the 1st of January or 1st of June. Hence, the difference UTC$-$UT1 is kept < 1 sec.

2.1.3 Setting defaults

ASTRO comes with a short precedure named `astro-site.astro`, located in the `pro` directory of your GILDAS installation. This file is executed at the beginning of each ASTRO session, and is used to set default values for the time and observatory parameters.

Name	Longitude	Latitude	Altitude (m)	Sun avoidance limit (deg.)	Antenna diameter (m)
NOEMA (or BURE or PDBI)	05:54:28.5	44:38:02.0	2560	32	15
PICOVELETA	-03:23:55.51	37:04:06.29	2850	2	30
ALMA	-67:45:11.6	-23:01:11.7	5000	0	12
APEX	-67:45:32.9	-23:00:20.8	5104	0	12
ATF	-107:37:10.02	34:04:29.8	2135	0	12
CSO	-155:28:31.8	19:49:20.78	4200	30	10
FCRAO	-72:21:00.0	42:23:24.0	0	0	14
JCMT	-155:28:37.2	19:49:22.11	4111	30	15
KITTPEAK	-111:36:54	31:57:12	1938	30	12
KOSMA	07:47:02.4	45:59:02.4	3089	30	3
NOBEYAMA	138:28:33.0	35:56:30.0	1350	30	10
SEST	-70:43:48	-29:15:24	2347	60	15
SMA	-155:28:52	19:49:33	4200	30	6
SMT (or HHT)	-109:53:28.48	32:42:05.8	3186	30	10
YEBES	-03:05:12.71	40:31:28.78	990	2	40
EFFELSBERG	06:53:02	50:31:29	360	20	100
GBT	-79:50:23.41	38:25:59.24	807	0	100
MEDICINA	11:38:49	44:31:15	25	30	
VLA	-107:37:06	34:04:42	2124	0	25
LASILLA	-70:43:48	-29:15:24	2347	60	
MAUNAKEA	-155:28:18	19:46:36	4200	60	
PARANAL (or VLT)	-70:24:11.642	-24:37:33.117	2636	60	
IOTA	-110:53:05	31:14:11	2608	60	
PTI	-116:51:47.88	33:21:24.12	1687	60	
GI2T	06:55:36	43:44:56	1270		

Table 2.1: Observatories known by the `OBSERVATORY` command. For interferometer, the coordinates correspond to the array center.The first part of this table lists the millimeter instruments: an antenna diameter is defined, to be used to compute angular resolution and planet brightness temperatures.

```
!
! Observatory and time initialization
!
astro\set dut1 -0.3    ! November 2007 Bulletin D 98 of IERS
astro\set dtdt 65.184  ! January 2006  Bulletin C 30 of IERS
!
astro\observatory      ! Select default observatory
astro\time           ! Use current system time
!
if (observatory.eq."BURE") then
   astro\set azimuth south
   astro\catalog gag_data:phase-pdb
   sic\message i site "Plateau de Bure defaults selected"
else if (observatory.eq."PICOVELETA") then
   astro\set azimuth north
   sic\message i site "Pico Veleta defaults selected"
else
   sic\message i site "No known defaults for this observatory"
endif
```

Note the `SET AZIMUTH NORTH|SOUTH` command, which is used to define the azimuth to be zero in the North or South directions, to conform to local conventions.

2.1.4 `HEADER` command

At any time during an ASTRO session, the `HEADER` command can be used to check the current time and observatory that have been selected. The output of the command also give sun-related information (sun rise, sun set, twilight times).

```
UTC :    19-SEP-2007   02:18:59.998
UT1 :    19-SEP-2007   02:18:59.698    D_UT1 :     -0.300
TDT :    19-SEP-2007   02:20:05.182    D_TDT :     65.184
Julian date :          2454362.60
LST :        02:33:06.1453

OBS :    BURE   05:54:28.500   44:38:02.000
Alt.:    2.560 km     Sun Avoidance:    45.0 deg.

SunRise/Set :      05:23:47.980   17:37:02.472
Twilight              Start           End
Civil :            18:10:55.799   04:49:54.653
Nautical :         18:45:21.460   04:15:28.992
Astronomical :     19:20:49.604   03:40:00.848
```

2.2 Computing source positions

2.2.1 Source catalogs

ASTRO uses source catalogs, that are selected by the `CATALOG name` command. File extension may be omitted when specifying the file name, the default is `.sou`. The catalog format is that used at the Plateau de Bure and Pico Veleta telescopes.

Catalogs in the old `OBSINP` input format, used at the IRAM 30-m Pico Veleta telescope until 2006, may also be read. The command is then `CATALOG /VELETA`. In that case, the input file (default extension `.cat`) is read and converted to the standard format; a file with the same name but extension `.sou` is created in the current directory.

In the ASTRO catalog format, each source uses one line of the catalog file. Each line should contain the following consecutive keywords (some may be omitted):

- Source name field:
  The source name field is a composite item which can accomodate several names for a single source. Names should be separated by a vertical bar `|` with no embedded spaces, e.g.:

  ```
  B0415+379|3C111
  ```

  Each name must have at most 12 characters.

- Coordinate system: 2 characters, optional. May be:
  - `EQ` for equatorial coordinates. If `EQ` is given explicitely, then the next keyword (equinox) is mandatory.
  - `GA` for Galactic II coordinates.
  - `EC` for J2000 Ecliptic coordinates
  - `HO` for horizontal coordinates
  - `DA` for equatorial, present-day coordinates.

- Epoch: needed for equatorial coordinates after `EQ` keyword.

- Longitude-like coordinate: in degrees, except for EQ and DA where it should be in hours. Format is hh:mm:ss.sss or dd.ddd or hh:mm.mmm.

- Latitude-like coordinate: in degrees, or hours for EQ and DA (same format as above).

- Velocity type: alphabetic code, can be `LSR`, `HELIO` or `EARTH`.

- Velocity: in km/second, in the corresponding reference frame (LSR, Heliocentric, or local. Default is zero.

- Intensity type: Either `FLUX` or `MAGNITUDE` (optional)

- Intensity: Either the Flux in Jansky or the magnitude (optional).

- Spectral index (optional).

A second catalog (known as the "ALTERNATE"catalog) may also be defined, using `CATALOG Name /ALTERNATE`. Commands `SOURCE`, `HORIZON` and `CONVERT` will take sources from this alternate catalog if used with the `/ALTERNATE` option. This enables easy switching between two classes of objects: for instance the project sources in the main catalog, and pointing sources or phase calibrators in the `ALTERNATE` catalog.

Example of catalog:

```
IRC+50096              3:22:59.000   47:21:19.00   LS -17.2
CRL618                 4:39:34.000   36:01:16.00   LS -21.3
IRC+10216              9:45:14.800   13:30:40.50   LS -27.0
CIT6                   10:13:11.000  30:49:17.00   LS -1.8
IRC-10236              10:14:35.000  -14:24:31.00  LS 3.3
YCVN                   12:42:47.000  45:42:48.00   LS 21.7
IRC+10420              19:24:26.700  11:15:11.00   LS 75.0
CRL2688                21:00:19.900  36:29:45.00   LS -36.0
NGC7027                21:05:09.400  42:02:03.00   LS 24.8
RCAS                   23:55:51.700  51:06:36.00   LS 22.0
OH26.5+0.6             18:34:52.500  -5:26:37.00   LS 27.0
OH104.9+2.4            22:17:42.500  59:36:16.00   LS -28.0
MUCEP88       EQ 1988.5 21:43:09.300  58:43:37.00   LS 0
ALIRA         EQ 2000.0 18:36:56.200  38:47:01.00   LS 0.
```

2.2.2 Source selection

Once a catalog has been defined, a source within this list can be selected using the `SOURCE name` command. The `/ALTERNATE` option will direct the search to the alternate catalog.

The source coordinates are reduced to current epoch (as defined by the last `TIME` command), and converted to horizontal coordinates azimuth and elevation relative to the observatory (as defined by the last `OBSERVATORY` command). Precession, nutation, aberration are taken into account. The motion of the Earth uses the ephemerides from the Bureau des Longitudes (BDL82). The source horizontal coordinates are printed on the screen, together with the line–of–sight components of the velocities of:

- the source relative to the observer (S/OBS)
- the source relative to the standard of rest (S/LSR)
- the standard of rest relative to the Solar System barycenter (LSR/G)
- and the Solar System barycenter relative to the observer (G/OBS)

All velocities are in km/s, counted positively for outwards motions. After running the `SOURCE` command, a number of `SIC` gloabal variables are updated and contain the source right ascension (variable `RA`), declination (`DEC`), azimuth (`AZIMUTH`) or elevation (`ELEVATION`). These are global `ASTRO` variables, used or mnodified by other commands. In addition, a structure called `astro%source%` is created, and contains all output values of the `SOURCE` command.

`SOURCE` with no arguments will compute positions of all sources from the current (or alternate) catalog in a row. The `SIC` variables will contain the position of the last source.

SOURCE /RESET will reset all source related parameters in ASTRO and remove the ASTRO%SOURCE structure.

2.2.3 Solar system bodies

The `PLANET name` command is similar to the `SOURCE` command, but the object must be a Solar System body. No catalog is used. Known objects are: SUN, MOON, MERCURY, VENUS, MARS, JUPITER, SATURN, URANUS, NEPTUNE. `PLANET` with no argument compute positions for all these objects.

Just like `SOURCE`, the `PLANET` command updated a number of `ASTRO` global variables (`RA`), `DEC`, `AZIMUTH`, `ELEVATION`). A structure called `astro%planet%` is also created, and contains all output values of the `PLANET` command.

In addition to the position, information is given on the planet's apparent size and position angle, its brightness temperature and flux at (sub)millimeter wavelengths, at the current frequency.

- The observing frequency (in GHz) is updated by modifying the value of the variable `FREQUENCY`. Default is 100 GHz.

- The beam of the telescope is computed by ASTRO, using the antenna diameter associated to the selected observatory (Table 2.1). This can however be modified by the user, by setting the `BEAM` variable to a non-zero value. The read-only `PRIMBEAM` variable contains the value actually used in the computation.

2.2.4 Precession

... CONVERT command ...

2.3 Plotting object positions

In addition to computing positions of sources or planets, ASTRO can also produce plots of sky areas with the requested source positions being indicated.

2.3.1 `FRAME` definition

The plotting frame is defined by the command `FRAME`. The frame may be in Equatorial coordinates (Righ Ascension–Declination) or in Horizontal coordinates (Azimuth–Elevation, as seen from the seleted observatory and at the time defined by the `TIME` command). These twe modes are selected by `FRAME EQ` or `FRAME HO` respectively.

The plotting may be done in rectangular coordinates using `FRAME HO` or `FRAME EQ`, with no other argument. If other arguments are given, a stereographic projection is used, which gives a better representation of the sky (distorsion of shapes is not too serious, but the scale of the map changes from the center of the projection to the edges). The projection is defined by its center coordinates and its size: for instance
`FRAME EQ ra dec size`
will use a projection centered in the requested direction, while the size parameter, in degrees, specify the plotting range (default is 180 degrees, i.e. a whole hemisphere). Similarly,

```
FRAME HO az el size
```

will produce a plot centered at the requested Azimuth and Elevation (in degrees). Caution: there are two possible azimuth definitions, depending on whether the azimuth is set to zero in

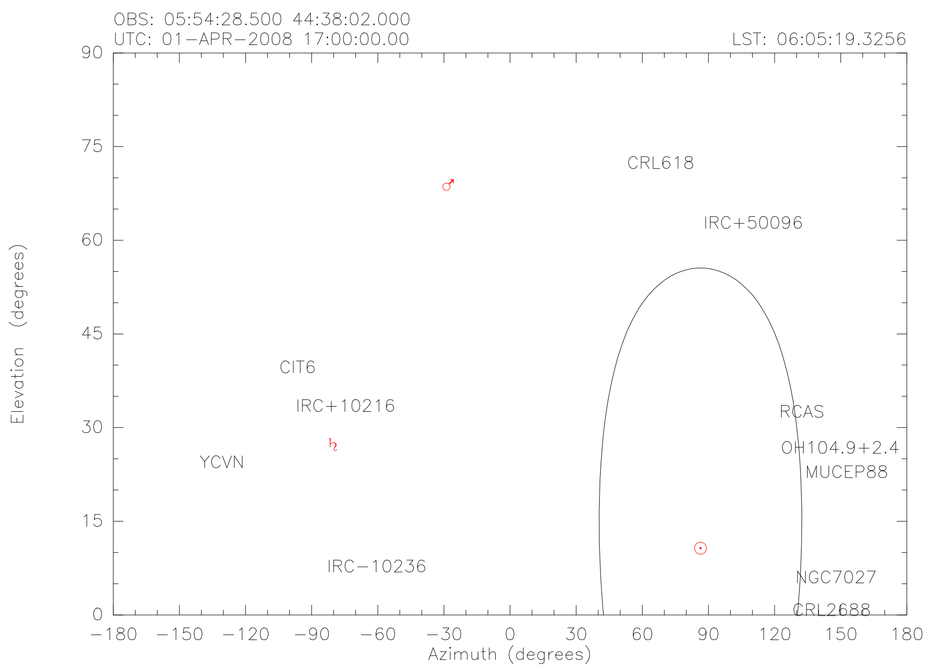


Figure 2.1: Example of plot produced by ASTRO: plotting source positions and sun avoidance circle in an horizontal frame.

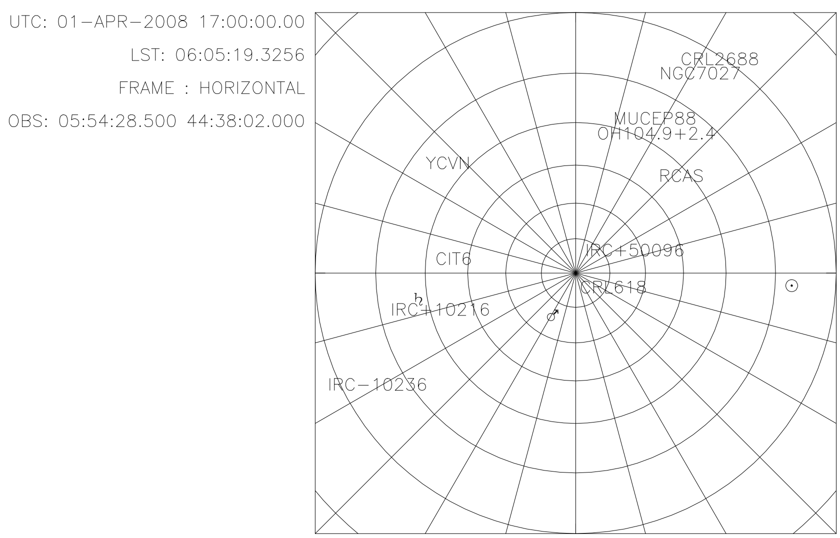


Figure 2.2: Example of plot produced by ASTRO: plotting source positions in an horizontal frame centered on zenith position.

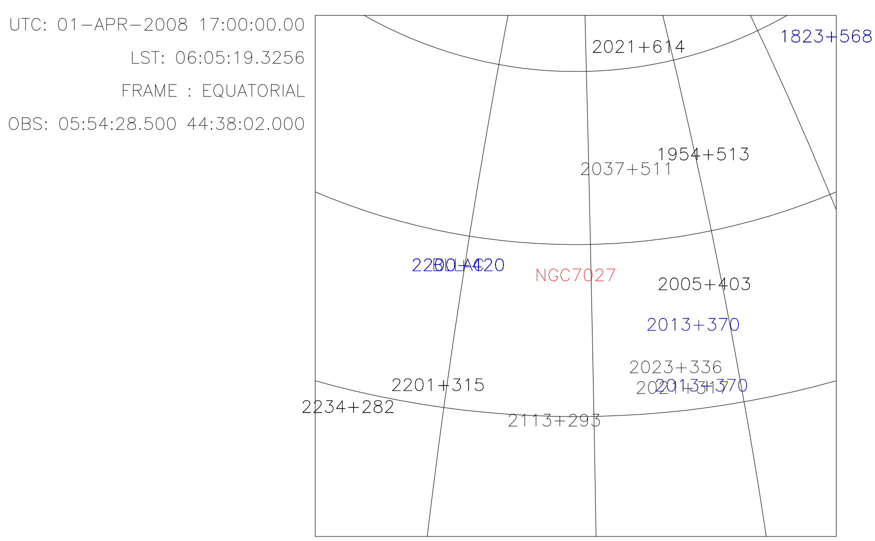


Figure 2.3: Example of plot produced by ASTRO: finding phase calibrators in the vicinity of NGC7027.

the North or South direction. The `SET AZIMUTH NORTH|SOUTH` command allows one to select one or the other convention.

Use of SIC variables is allowed to select frames such as

```
FRAME EQ RA*12/PI DEC*180/PI 45
```

which selects a frame of size 45 degrees, in equatorial coordinates, centered on the last computed object position. A few short cuts are available to produce a number of useful, classical plots:

- `FRAME HO ZENITH` gives the whole sky above the horizon, centered on the zenith position. It is equivalent to `FRAME HO 0 90 180` in the `SET AZIMUTH SOUTH` convention, or `FRAME HO 180 90 180` in the `SET AZIMUTH NORTH` convention.

- `FRAME HO SOUTH` gives the visible sky above the southern horizon. It is equivalent to `FRAME HO 0 60 120` in the `SET AZIMUTH SOUTH` convention, or `FRAME HO 180 60 120` in the `SET AZIMUTH NORTH` convention.

- `FRAME HO NORTH|EAST|WEST` are also possible, to plot the visible sky above the north, east, and west horizon respectively.

2.3.2 Plotting sun avoidance region

The `TIME` command already described above also plots the sun avoidance region. This is not done automatically by `FRAME`, so that the user can produce time-independant plots. Alternativelly, entering several `TIME` commands in a row allows to produce plots with different sun avoidance regions being plotted. `TIME /NODRAW` can be used to suppress the plotting of the sun avoidance circle.

Finally, the command `HEADER` will label the plot with the times (LST, UTC) and dates. Again, this is independant from `FRAME` and `TIME`, so that the user can have a full flexibility to define the plot and labels.

2.3.3 Plotting source or planet position

In addition to computing the coordinates, the commands `SOURCE /DRAW` and `PLANET /DRAW` will also indicate the position of the requested source in the current plot (as defined by `FRAME`). Arguments to the `/DRAW` option may be:

- `LINE`, to plot a line from the previously computed position

- `MARKER`, to plot the current GREG marker at the computed position (with a size corresponding to the source flux in the catalog, for the `SOURCE` command).

- `SYMBOL` to plot the source name (`SOURCE` command) or the usual planet symbol (`PLANET` command)

- `FULL`, to combine `MARKER` and `SYMBOL` (the sourcee name or planet symbol will be offset one marker size above the computed position).

The default argument of `/DRAW` is `SYMBOL`. Another very useful option of the `SOURCE` command is `SOURCE /FLUX min_flux`, that selects only the sources whose flux is larger that the `min_flux` value.

Examples — Below are a few examples of plots produced by the commands described in this section. A large variety of plots can be produced, depending on the user's purposes.

The following commands plot the position of the sources in the sky at 03:00 UT on April 1st 2008, together with the position of planets (Fig. 2.1, only Jupiter is up):

```
CATALOG GAG_DEMO:SAMPLE.SOU          ! define the catalog
OBSERVATORY BURE                     ! define the observatory
FRAME HORIZON                        ! plots the whole visible sky
TIME 03:00 01-APR-2008               ! define the time & plot sun avoidance
SOURCE /DRAW                         ! draw all sources from catalog
PEN 1                                ! select pen 1 (red)
PLANET /DRAW                         ! draw all planets
PEN 0                                ! select pen 0 (black)
HEADER                               ! label the plot.
```

The same plot, but seen in a different projection (from zenith position, see Fig. 2.2), is produced by:

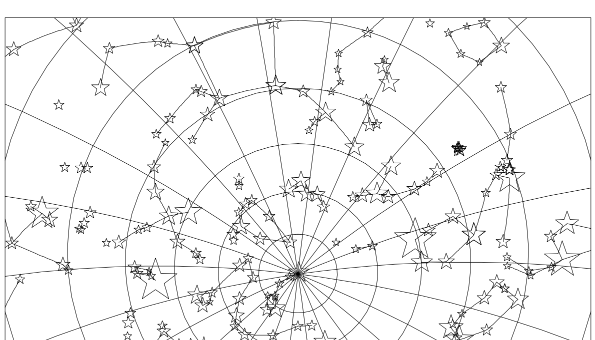
```
CATALOG GAG_DEMO:SAMPLE.SOU          ! define the catalog
OBSERVATORY BURE                     ! define the observatory
TIME 03:00 01-APR-2008               ! define the time
FRAME HORIZON ZENITH                 ! plots the whole visible sky
SOURCE /DRAW                         ! draw all sources from catalog
PLANET /DRAW                         ! and planets (only Jupiter is up)
HEADER                               ! label the plot.
```

The following commands sequence plots the phase calibrators close to NGC 7027 (Fig. 2.3):

```
CATALOG GAG_DEMO:SAMPLE.SOU          ! selects the source catalog
CATALOG GAG_DEMO:PHASE /ALTERNATE    ! selecs the calibrators catalog
OBSERVATORY BURE                     ! define he observatory
TIME 03:00 01-JAN-1990               ! define the time
SOURCE NGC7027                       ! get source position
FRAME EQ RA|PI*12 DEC|PI*180 45      ! frame EQ, centered on source,
                                     ! 45 degrees in total size
PEN 1                                ! red pen
SOURCE NGC7027 /DRAW                 ! plot source position
PEN 0                                ! black pen
SOURCE /DRAW /ALTERNATE              ! draw phase calibrators
HEADER                               ! label the plot
```

2.3.4 Constellations drawing

The `CONSTELLATION` command plots the main constellations stars in the `FRAME` area, using the current pen and marker. The marker size will scale acrording to the star magnitude. Options are available to draw lines between stars (to form classical constellation outlines) or plot the star



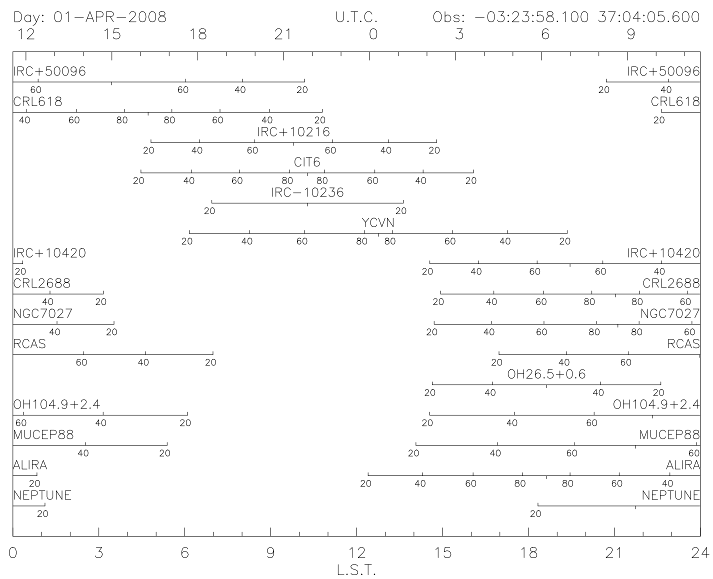


Figure 2.5: Plotting an observability chart.

names. See the corresponding section of language internal help for details.

Example – Figure 2.4 shows the plot resulting from the commands:

```
FRAME EQ 12:32:54 75:30:33 180.0  ! an equatorial frame
GREG\SET MARKER 5 2 1
CONSTELLATION /DRAW M L           ! draws the stars and the lines
```

2.4 Observability bar charts

A extremely convenient mean of planning observations is to produce a diagram in which time is used as x–coordinate, and in which an horizontal bar is drawn for each selected source to indicate the time period during which the source is up. Such a plot is produced using the command `HORIZON`. One may use all sources in the current catalog (`HORIZON /SOURCE`), all planets (`HORIZON /PLANET`), or both. Specific objects may be called by their names using `HORIZON /SOURCE name1 name2 ...` or `HORIZON /PLANET name1 name2 ...`. A source that is presently in the sun avoidance circle is written within brackets ([]) and in italics (e.g. [*NGC 2264*]). When a quite long catalog is used, the command `HORIZON /SOURCE NEXT n` can be used repetitively to obtain plots with only `n` objects at a time.

Example – The following commands will plot the observability hours for the sources of the `sample.sou` catalog on April 1stst 2008, together with planet Neptun. The output is presented in Fig. 2.5.

```
CATALOG GAG_DEMO:SAMPLE.SOU        ! define the catalog
OBSERVATORY PICOVELETA             ! ... the observatory
TIME 12:00 01-APR-2008             ! ... and the time
HORIZON /SOURCE /PLANET NEPTUN     ! produce the plot
```

Chapter 3

Millimeter-wave observations

3.1 Atmospheric effects

... ATMOSPHERE command ...

Chapter 4

Planning observations with the Pico Veleta antenna

4.1 Receiver and correlator setup

Since 2016, a set of commands have been developed in ASTRO in order to help users when preparing receiver and correlator setups for EMIR observations. The commands are: EMIR, BASEBAND, and BACKEND.

Note that the generic ASTRO commands CATALOG, SET LINES and SET FREQUENCY can be used to optimize the plots produced by EMIR and BACKEND.

The full documentation not yet written but one can refer to the internal HELP and to a dedicated tutorial available on the GILDAS web page (http://www.iram.fr/IRAMFR/GILDAS/, tutorial section).

Chapter 5

Planning observations with the NOEMA observatory

5.1 Introduction

In ASTRO, the observatory name “NOEMA” refers to NOEMA after the delivery of its correlator (PolyFix) in 2017.

Older states of the hardware are available under the PDBI (or BURE) observatory name. Different version can be set up through command OBSERVATORY BURE 'pdbi_year'.

5.2 Receiver and correlator setup

Since February 2017, a set of commands have been developed in ASTRO in order to help users when preparing receiver and correlator setups for NOEMA observations. The main commands are: TUNING, BASEBAND, and SPW. Other useful commands are LIST, RESET, and PLOT to visualize and manage the configured spectral windows. The online proposal management system requires an ASTRO script as input. This script can be obtained through the PROPOSAL command once the desired hardware configuration has been reached.

Note that the generic ASTRO commands CATALOG, SET LINES and SET FREQUENCY can be used to optimize the plots produced by TUNING, BASEBAND, SPW and PLOT commands.

The full documentation not yet written but one can refer to the internal HELP and to a dedicated tutorial (including new NOEMA nomenclature definition) is available on the GILDAS web page (http://www.iram.fr/IRAMFR/GILDAS/, tutorial section)

Chapter 6

Planning observations with the Plateau de Bure interferometer

6.1 Introduction

In ASTRO, the name Plateau de Bure interferometer refers to the NOEMA observatory as it was before the delivery of the NOEMA correlator (PolyFix) in 2017. The following refers to this state of the hardware (so-called *new generation)* of receivers installed in 2006 and NarrowBand + Widex correlator.

Older states of the hardware are available through the "OBSERVATORY BURE PDBI_YEAR" command, where year can be 1995,2000,2006,2013, or 2015. See internal HELP for details.

6.2 Receiver and correlator setup

The current generation of receivers at the Plateau de Bure is composed of **four receivers bands**, tuned **SSB**, each of them including **two polarization channels**. At any given time, only one receiver is used, but with the two polarizations. Each polarization delivers 4 GHz. The **narrow-band correlator** accepts as input two signals of 1 GHz bandwidth, that can be selected within the 2×4 GHz delivered by the receiver. A **wide-band correlator**, processing the whole 2×4 GHz is currently being built. The receivers bands are as follows:

Band 1	80–117 GHz	(3 mm window)
Band 2	129–174 GHz	(2 mm window)
Band 3	200–267 GHz	(1.3 mm window)
Band 4	277–371 GHz	(0.8 mm window)

To prepare Plateau de Bure observations, ASTRO includes a series of commands to simulate the receivers tuning and backend setup.

6.2.1 Receiver setup

The receiver tuning is selected by the `LINE` command, which has the same syntax as the corresponding command in the `OBS` software on Plateau de Bure:

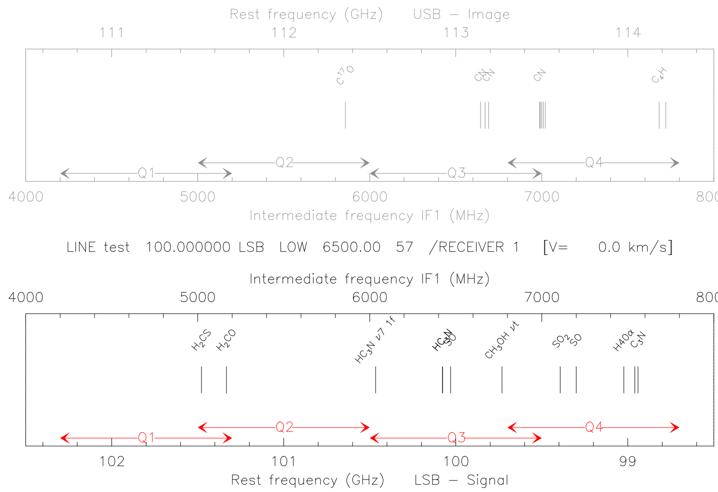


Figure 6.1: Plateau de Bure frequency coverage: ouptut of `LINE test 100 LSB`. Both the LSB and USB frequency coverages are displaye.

`LINE name frequency band lock center harm /RECEIVER_BAND irec`

`name` is a line name, only used to label the plot; `frequency` is the rest frequency in GHz; `band` should be USB or LSB; `lock` is LOW or HIGH [optional, default LOW]; `center` is the IF1 frequency (in MHz) that must correspond to the required rest frequency [optional, default 6500]; `harm` is the harmonic number [optional, reserved for experts]. The `/RECEIVER_BAND` option is optional, the software will automatically find the appropriate receiver band, depending on the rest frequency.

It is highly recommended *not* to center the line at 6 GHz. This is because the correlator will analyse four 1 GHz-wide slices of the 4 GHz bandwidths, and 6 GHz is very precisely at the limit between two such adjacents quarters (see below).

The `LINE` command produces a plot of both the LSB and USB frequency coverage (the non-selected band being in light grey). The four quarters that are analyzed by the IF/correlator system are indicated by horizontal arrows (see Fig. 6.1). Vertical lines indicate the positions of the main molecular lines.

6.2.2 Correlator setup

The details of the IF processor and narrow-band correlator frequency plan is presented in another document. In short: the input 4–8 GHz band is split by the IF processor in four 1 GHz parts, labeled **Q1, Q2, Q3, Q4**. This processing is done in parallel for both polarizations. Since the narrow-band correlator accepts only two 1 GHz input signals, one has to define which part (=which quarter of which polarization) of the signal is to be sent to the correlator. The system allows the following choices:

- first correlator input can only be Q1 HOR, Q2 HOR, Q3 VER, or Q4 VER

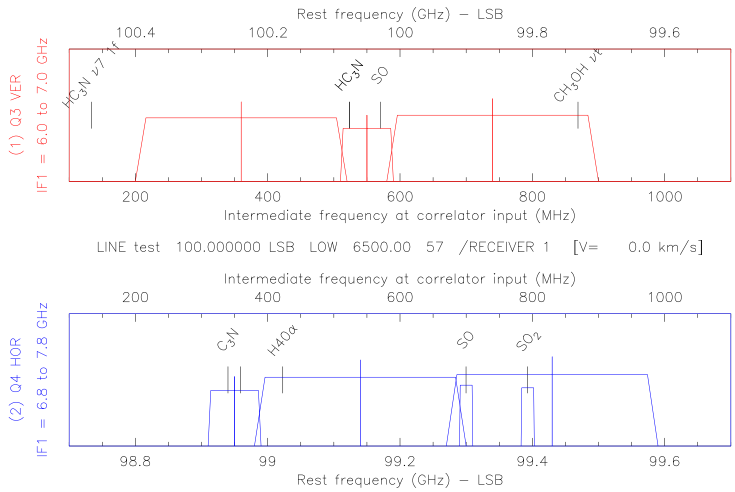


Figure 6.2: Plateau de Bure frequency coverage: ouptut of LINE; NARROW; SPECTRAL commands.

- second correlator input can only be Q1 VER, Q2 VER, Q3 HOR, or Q4 HOR

where HOR and VER refers to the two polarizations and Q1...Q4 to the four quarters of the input 4 GHz signal. Note, that these quarters are 1 GHz wide but are covering only 3.6 GHz in total (due to filters' edges), hence an overlap between Q1 and Q2 on one side, and Q3 and Q4 an the other side:

Q1 = 4.2–5.2 GHz
Q2 = 5.0–6.0 GHz
Q3 = 6.0–7.0 GHz
Q4=6.8–7.8 GHz.

The command

```
NARROW_INPUT Q1|Q2|Q3|Q4 Q1|Q2|Q3|Q4
```

allows one to select the two entries of the narrow-band correlator. The polarization is determined from the above list. For instance, `NARROW_INPUT Q1 Q2` selects Q1 as the first correlator entry – this can only be Q1 HORizontal– and Q2 as the second correlator entry – this can only be Q2 VERtical. Selecting two times the same quarter (e.g. `NARROW Q2 Q2`) results in both polarization being observed simultaneously, in the same frequency range.

`NARROW_INPUT` produces a new plot, where the frequency coverage of the two selected quarters are displayed. After that step, the `SPECTRAL` command is used to defined and plot the positions and widths of each of the 8 units of the correlator. The syntax is:

```
SPECTRAL iunit bandwidth fcenter /NARROW 1|2
```

where:

- `iunit` is the correlator unit number (1 to 8);
- `bandwidth` is the bandwidth in MHz (20, 40, 80, 160, or 320);
- `fcenter` is the center frequency (in MHz) of the unit in the second IF (in the range 100 to 1100 MHz);
- the option `/NARROW` is mandatory, to select which entry of the correlator the unit is connected to.

Example – Figure 6.2 presents the plot produced by the command sequence:

```
LINE test 100 LSB
NARROW Q3 Q4
SPECTRAL 1  80  550 /NARROW 1
SPECTRAL 2  80  350 /NARROW 1
SPECTRAL 3  20  793 /NARROW 1
SPECTRAL 4  20  700 /NARROW 1
SPECTRAL 5 320  360 /NARROW 1
SPECTRAL 6 320  740 /NARROW 1
SPECTRAL 7 320  540 /NARROW 1
SPECTRAL 8 320  830 /NARROW 1
```

6.2.3 Fine-tuning the plot

The `LINE`, `NARROW`, and `SPECTRAL` commands produce plots that display the receiver and correlator setup of the instrument. Those plots can be further modified using the `PLOT` command, to e.g.:

- swap from a DSB-like plot (LSB and DSB reprensented) to a NARROW-like plot (two selected quarters are displayed), using `PLOT DSB|NARROW`;
- zoom on a particular IF region, typically if many lines are present, using `PLOT /LIMITS min max`;
- introduce a width for the molecular lines displayed (`PLOT /WIDTH width`);
- plot the location of possible spurious lines (`PLOT /SPURIOUS`).

See the on-line help for more details on the input parameters.

6.2.4 Producing setups

Once the `LINE`, `NARROW`, and `SPECTRAL` commands have been used to define the tuning of the receiver and backend, the command `PRINT filename` allows one to write in an output file the corresponding `OBS` commands. This file can directly be included in the observing procedure ("setup" file) to be run at the Plateau de Bure.

```
!
! Plateau de Bure receiver and backend setup
! Written by ASTRO command PRINT on 11-FEB-2008
!
! ----- Receiver -----
```

```
!
LET RECEIVER 1
LINE LINE test  100.000000 LSB  LOW  6500.00  57 /RECEIVER 1
!
! ----- IF processor -----
! Selected quarters are Q3 VER and Q4 HOR
!
NARROW Q3 Q4 /RECEIVER 1
!
! ----- Narrow-band correlator -----
!
SPECTRAL 1  80  550.00 /NARROW 1 /RECEIVER 1
SPECTRAL 2  80  350.00 /NARROW 2 /RECEIVER 1
SPECTRAL 3  20  793.00 /NARROW 2 /RECEIVER 1
SPECTRAL 4  20  700.00 /NARROW 2 /RECEIVER 1
SPECTRAL 5 320  360.00 /NARROW 1 /RECEIVER 1
SPECTRAL 6 320  740.00 /NARROW 1 /RECEIVER 1
SPECTRAL 7 320  540.00 /NARROW 2 /RECEIVER 1
SPECTRAL 8 320  830.00 /NARROW 2 /RECEIVER 1
```

6.2.5 Old receiver systems

The above description refers to the "new generation" receivers installed during the winter 2006–2007 (3 and 1.3 mm bands) together with the new IF processor. The system was completed in 2007–2008 with the 2 mm band, and should be further developed in the next years (0.8 mm band, new wide-band correlator). The `LINE` command allows one to produce plots using the old receiver and backend system, to be able to check old Plateau de Bure data. The command `SET PDBI 1995|2000|2006` is used to select the status of the instrumentation in the year:

- 1995: 3 and 1.3 mm receivers, 500 MHz bandwidth (from IF 100 to 600 MHz).
- 2000: 3 and 1.3 mm receivers, 580 MHz bandwidth (from IF 100 to 680 MHz).
- 2006: new generation receivers and new IF processor (this is the default)

For the old receivers (1995 and 2000), the `NARROW`, `SPECTRAL`, and `PLOT` commands are not relevant. Instead, the `LINE` command has a series of options, the most important one being `LINE /SPECTRAL iunit bandwidth fcenter` to plot the position and width of the correlator spectral units (see on-line help for all options). The plots that are produced are always `DSB`-like. Note that the doppler correction is of some importance for the old receivers, because these receivers were (or could be tuned) DSB. Indeed, doppler tracking is correct only in the signal sideband. The doppler correction is correct in the image sideband when the frequency is loaded by **OBS** at the Plateau de Bure, but subsequent tracking is computed for the signal side band only. The tracking error in the image side band is 0.04 km/s at 86 GHz, in the worst case. This is now unrelevant for the current Plateau de Bure receivers, which are SSB.

6.3 Predicting uv coverage

.... UV_TRACK...

6.4 GUI wizards

The ASTRO window interface includes a submenu “Pateau de Bure” that give acces to a few procedures specific to the Plateau de Bure interferometer.

6.4.1 Sensitivity estimate

6.4.2 Finding calibrators

Chapter 7

Internal Help

7.1 ASTRO language internal help

7.1.1 Language

```
                        ASTRO\ Language summary

    ATMOSPHERE          : compute atmospheric parameters
    CATALOG             : opens a standard source or line catalog
    CONVERT             : precess coordinates from an input catalog
    CONSTELL            : draws constellation on current plot
    FRAME               : define plotting reference system
    HORIZON             : plot observability hours of sources and planets
    HEADER              : write time parameters on top of plot
    OBSERVATORY         : define current observatory
    PLANET              : compute planet coordinates
    SET parameter value : enter some parameter value
    SHOW                : display variable defined with SET, OBSERVATORY, and TI
    SOURCE              : compute source coordinates and velocities
    TIME                : set computation time
    UV_TRACKS          : plot interferometer UV tracks
```

7.1.2 ATMOSPHERE

```
        [ASTRO\]ATMOSPHERE  [INTERPOLATE|MAKE|SAVE]  [/PRINT]  [/FREQUENCIES
    SIGVAR IMAVAR]

    Compute atmospheric emission, opacity, system temperatures, etc...,  us-
    ing input parameters provided by the user. Input parameters are the fol-
    lowing SIC variables:
       TEMPERATURE      Outside temperature
       ZERO_PRESSURE    Pressure at sea level.
       AIRMASS          Number of air masses
       WATER            Precipitable water vapor
       FORWARD_EFF      Forward efficiency
       GAIN_IMAGE       Receiver gain ratio
```

```
   TREC             Receiver temperature
   FREQ_SIG         Signal frequency (in GHz)
   FREQ_IMA         Image frequency (in GHz)
These variables can be assigned using the SIC command  LET.   The  addi-
tional input variables
   ALTITUDE         Site altitude
   FREQ_SIG         Signal frequency (in GHz)
   FREQ_IMA         Image frequency (in GHz)
are modified by the ASTRO OBSERVATORY and LINE commands.
Option /PRINT displays all these inputs.

The output of the command consists in the following variables
   TRUE_PRESSURE    Local pressure, derived from the site altitude and
                    the sea level pressure by the scale height of 5.5 km.
   TSYS             The system temperature in the signal sideband
   TAU_H2O          The water vapor opacity
   TAU_O2           The dry atmosphere opacity (mostly due to Oxygen,
                    but minor constituents like Ozone may also play a role)
   TAU_TOT          The total opacity: H2O + O2 (+ minor components for
                    new ATM versions)
   EMIS_SIG         The atmospheric emission (Kelvin) in the signal sideband
   EMIS_IMA         The atmospheric emission (Kelvin) in the image sideband
   PATH_SIG         The atmospheric excess optical path length (mm)
                    in the signal sideband
   PATH_IMA         The atmospheric excess optical path length (mm)
                    in the image sideband
   ATM_SIG          The atmosphere temperature in the signal sideband
   ATM_IMA          The atmosphere temperature in the image sideband
   TANT             The antenna temperature
These  variables can then be used to produce plots of atmospheric trans-
parency, system temperatures, etc. By default, the command computes  the
atmospheric  parameters  for  a single pair of signal and image frequen-
cies. To compute the parameters for a list of  frequencies,  use  option
/FREQUENCIES (see subtopic for details).

ATMOSPHERE INTERPOLATE
will do the same calculations, but interpolating the data from the bina-
ry table (as defined by logical name GAG_ATMOSPHERE). The whole table is
loaded  in  internal  buffers  which  can  be  accessed in the structure
ATM%TABLE% for use in procedures.

ATMOSPHERE MAKE filename nf freqmin freqmax
will create the binary table filename.bin  for  nf  frequencies  between
freqmin  and freqmax (in GHz). See subtopic FORMAT for details about the
binary format used.

ATMOSPHERE SAVE filename
```

```
will save inside filename.bin the  binary  table  currently  in  memory.
This  is useful to save with the current machine byte order a table pre-
viously computed on a different machine with a different byte order.
```

ATMOSPHERE FORMAT

```
The ATM values are saved in binary files which use an ad-hoc format  (in
particular, this is not the Gildas Data Format). They are Fortran unfor-
matted (binary) files, usually read in direct access mode with 128 words
(512  bytes) records. The values are written in the current machine sys-
tem (IEEE, EEEI, ...); this system is saved as the very  first  word  in
the file.

The  file  consists  in a succession of tables describing the opacities,
atmospheric emission, and optical length in the space of pressure,  tem-
perature, frequency, water vapor, and airmass. The values in the tables,
and the tables themselves, are written contiguously (no blanks  inserted
e.g. no alignment on the records). Here is the exact sequence:

Code    C*4  [     ]  System code

Np      I*4  [     ]  Number of pressure values
Nt      I*4  [     ]  Number of temperatures
Nf      I*4  [     ]  Number of frequencies
Nw      I*4  [     ]  Number of precipitable water vapor amounts
Na      I*4  [     ]  Number of airmass values

P[Np]   R*4  [HPa  ]  Pressure values
T[Nt]   R*4  [K    ]  Temperaure values
F[Nf]   R*4  [GHz  ]  Frequencies
W[Nw]   R*4  [mm   ]  Precipitable water vapor amounts
A[Na]   R*4  [     ]  Airmass values

tauox[Nf,Nt,Np]         R*4  [neper] Opacity (dry component)
tauw[Nf,Nt,Np]          R*4  [neper] Opacity (wet component)

Temis[Na,Nw,Nf,Nt,Np]  R*4  [K    ] Atmospheric emission
Path[Na,Nw,Nf,Nt,Np]   R*4  [cm   ] Optical length
```

ATMOSPHERE /FREQUENCIES

```
    ATMOSPHERE /FREQUENCIES SignalVar [IntermediateFrequency]

Vectorized version of the ATMOSPHERE command.

In  this  case, the input parameters are identical to the non-vectorized
form (in particular, they are still scalar) except FREQ_SIG and FREQ_IMA
```

```
which  are  ignored. The list of signal frequencies is read instead from
the first variable passed to the option. It can be scalar or vector.

If an intermediate frequency is also provided, a list of image  frequen-
cies  is  derived  from the signal frequencies, symetric with respect to
the IF. If the IF is absent, image frequencies are defined identical  to
the  signal  frequencies, but still used in the ATM computation (in par-
ticular this gives a decent continuum estimation if  GAIN_IMAGE  is  non
zero). Set GAIN_IMAGE to zero to remove any image contribution.

The  atmospheric  excess optical path length is NOT computed by this op-
tion. Frequencies are all expected in GHz.

In return, the command stores vectorized products in the following user-
defined variables:
  ATM%TSYS
  ATM%TAU_H2O
  ATM%TAU_O2
  ATM%TAU_TOT
  ATM%EMIS_SIG
  ATM%EMIS_IMA
  ATM%PATH_SIG
  ATM%PATH_IMA
  ATM%ATM_SIG
  ATM%ATM_IMA
  ATM%TANT
  ATM%IER         ! Error status for each frequency
Their dimensions match the input frequency lists.
```

7.1.3 CATALOG

```
    [ASTRO\]CATALOG name [/VELETA] [/ALTERNATE] [/SOURCE] [/LINE]

Open  the  catalog  file specified by 'name'. It can be a source catalog
(if /SOURCE or /ALTERNATE is present, or if the extension is .sou, or by
default  if  none is present), or a line catalog (if /LINE option, or if
the extension is .lin).

See HELP CATALOG FORMAT for a description of the  source  catalogs  con-
tent.  The directory GAG_DEMO: contains two examples of source catalogs,
sample.sou and phase.sou (an incomplete list of Plateau  de  Bure  phase
calibrators).  The  file GAG_DATA:phase-pdb.sou contains a more complete
list of Plateau de Bure phase calibrators.

The line catalog can be used to draw  the  position  of  known  spectral
lines  when plotting the frequency coverage of EMIR, NOEMA or ALMA.  See
HELP CATALOG /LINE for details.
```

CATALOG with no arguments will display the catalogs currently opened.

CATALOG /ALTERNATE

This option will open the specified source catalog as a second catalog, only accessible through the "/ALTERNATE" options of commands SOURCE, HORIZON, and CONVERT. For instance, a catalog containing calibration or pointing sources may be opened as an Alternate Source catalog, while the objects to study are kept in the Current catalog, enabling easy switching between the two kinds of objects.

CATALOG /LINE

```
[ASTRO\]CATALOG Name /LINE
```

Indicate we are specifying the line catalog.

The line catalog can be used to draw the position of known spectral lines when plotting the frequency coverage of EMIR (commands PICO\EMIR,BACKEND) and NOEMA (commands NOEMA\TUNING,BASEBAND,SPW,PLOT).

To do so one should first use "SET LINES ON" (see HELP SET LINES for details). GILDAS provides an internal line catalog (GAG_DATA:molecules.dat) used as a default.

The line catalog format is:

```
  Freq(In GHz) 'LineName'
  230.538            'CO (2-1)'
```

Lines starting with "!" are regarded as comments and are ignored.

CATALOG /SOURCE

Indicate we are specifying the source catalog

CATALOG /VELETA

This option will open the catalog file 'name'.CAT, assuming it follows the format of OBSINP catalogs in use on the 30m Radiotelescope of IRAM instead of the default GILDAS format (see HELP CATALOG FORMAT).

A file 'name'.SOU will be created in the current directory in the Plateau de Bure format, so that this option needs to be specified ONLY ONCE for each catalog. Fancy keywords in the catalog such as SLOP, SBOP

```
... are not supported.
```

CATALOG FORMAT

```
   In the ASTRO source catalog format each source uses one line of  the
catalog  file.   Each line should contain the following consecutive key-
words (some may be omitted):
 1) Source name field:
    The source name field is a composite item which can accomodate several
    names for a single source. Names should be separated by a vertical bar
    ( | ) with no embedded spaces, e.g.: B0415+379|3C111. Each name must
    have at most 12 characters.
 2) Coordinate system: 2 characters, optional, may be:
      EQ for equatorial coordinates. If "EQ" is given explicitely,
                           then the Equinox value is mandatory.
      GA for Galactic II coordinates.
      EC for J2000 Ecliptic coordinates
      HO for horizontal coordinates
      DA for equatorial, present-day coordinates.
 3) Equinox: needed for equatorial coordinates after "EQ" keyword.
 4) Longitude-like coordinate: in degrees, except for EQ and DA where it
    should be in hours. Format is
          hh:mm:ss.sss[,first[,second]]
    where
          "hh:mm:ss.sss" is a generalized sexagesimal format
            (hh:mm:ss.sss or dd.ddd or hh:mm.mmm)
          "first" is an (optional) first order time derivative
          "second" is an (optional) second order time derivative
 5) Latitude-like coordinate: in degrees, same format as above.

 The following OPTIONAL keywords can also be included, and may be listed in
 any order:

 A) a "Velocity" keyword
     Velocity Value
        where "Velocity" is an alphabetic code, equal to "LSR", "HELIO",
        or "EARTH". HELIO actually means: referred to the Solar System
        barycenter. Value is the velocity in km/second, in the corresponding
        reference frame. Default is zero.
 A') the "REDSHIFT" keyword
     Redshift Value
        Value is the redshift value.
        The user may provide a redshift OR a velocity, not both.
 B) an "Intensity" keyword
     FLUX  Value [Index]
         Value is the flux in Jy. Index is an optional spectral index
```

```
    Mx  Value
        Value is the magnitude, Unknown values can be coded 99.99
        Mx can be MAGNITUDE, or x is one of V,R,I,J,H,K,L,M,N to indicate
        the visual band
C) a "Project" keyword
    PROJECT ProjectID
       to specify a project identification (a string without spaces)
D) an "hour" keyword to indicate the validation hour for the coordinates
   (which is useful when time  derivatives are given), specified by
    HOUR Value
E) A "Parallax" keyword
    PARALLAX Value
         Value is in arcsec.

Any other keyword will be ignored.
```

7.1.4 CONSTELL

```
    [ASTRO\]CONSTELL [/DRAW [m] [l] [s]] [/BOUNDARIES]

Plots in the current FRAME with the current FONT, MARKER  and  PEN,  the
constellations, i.e., the main stars of all constellations with a marker
size adequately depending on the magnitude.  The options are:
 /DRAW [m] [l] [s]
 "m" will cause markers at the star's positions to be plotted
 "l" will cause the constellations outlines to be plotted
 "s" will cause the star's names to be plotted (using current centering and
     character size)
 /BOUNDARIES will draw the constellation boundaries (originally
     constant RA and DEC at 1875 equinox, they are precessed to the
     current equinox).  The current code is quite slow.

The default is CONSTELL /DRAW m l. This command makes use of the logical
name  GAG_CONSTELL  which  points to a GILDAS Table containing the stars
positions (constellation.bin bydefault) and drawing codes, and  GAG_CON-
ST_BOUND which defines the constellation boundaries (file sky.bin by de-
fault).
```

7.1.5 CONVERT

```
    [ASTRO\]CONVERT [Catalog_Name] [/ALTERNATE]  [/J2000  [Obs_equinox]]
[/PRECESS [New_equinox]] [/GALACTIC] [/FLUX fmin] [/NAME ncname [iname]]
[/INPUT POS|FLUX filename pos]

Change catalog format or equinox.

With the /J2000 and/or /PRECESS option, the  command  will  precess  the
```

current SOU catalog to J2000 system, using the specified equinox for observation (Obs_equinox, default 1950) and final result (New_equinox, default 2000). The output catalog is 'Catalog_name'.SOU, and has the standard format.

/FLUX create a copy of the current catalog with only sources of flux larger than fmin

/NAME ncname [iname]: reserve ncname characters for names field. With iname.gt.0, a standard name (Jhhmmmsddmmm) is created and put in inameth positions in the list of names.

/INPUT FLUX filename : will take fluxes from filename, which has itself the format of a catalog (both input catalog and filename are assumed alphabetically sorted)

/INPUT POSITION filename dpos : will take positions from filename, if different by more than dpos arc seconds. Filename has itself the format of a catalog (both input catalog and filename are assumed alphabetically sorted)

/ALTERNATE option : do the same operation with the Alternate catalog.

7.1.6 FRAME

```
[ASTRO\]FRAME System [...]
```

```
This command specifies the reference frame to be used for plots.  System
may  be HORIZONTAL or EQUATORIAL (at equinox defined by TIME command) If
no other argument is given, plotting is done in rectangular  coordinates
representing Azimuth-Elevation or Right Ascension-Declination.  If other
arguments are given, a Stereographic projection is used:
  - FRAME EQUATORIAL Ra Dec Size
    the projection will be centered on Ra and  Dec  (hours  -  degrees);
    Size  in  degrees  specify  the plotting range (e.g. 180 for a whole
    hemisphere = the default).
  - FRAME HORIZONTAL Az El Size
    same thing, but Az and El are in degrees.
  - FRAME HORIZONTAL Center
    will plot a hemisphere in horizontal system,  where  Center  may  be
    ZENITH, NORTH, EAST, SOUTH or WEST.
```

7.1.7 HEADER

```
[ASTRO\]HEADER
```

Write the UTC and LST times on top of the FRAME plot, as well as the observatory coordinates.

```
The same information, as well as a  couple  of  other  parameters  (.eg.
twilight  start  and  end),  are listed in the ASTRO terminal. Output is
something like:
  UTC :    19-SEP-2007   02:18:59.998
  UT1 :    19-SEP-2007   02:18:59.698    DUT1 :     -0.300
  TDT :    19-SEP-2007   02:20:05.182    DTDT :     65.184
  Julian date :          2454362.60
  LST :       02:33:06.1453

  OBS :    BURE   05:54:28.500   44:38:02.000
  Alt.:    2.560 km     Sun Avoidance:    45.0 deg.

  SunRise/Set :      05:23:47.980   17:37:02.472
  Twilight              Start          End
  Civil :            18:10:55.799   04:49:54.653
  Nautical :         18:45:21.460   04:15:28.992
  Astronomical :     19:20:49.604   03:40:00.848
```

7.1.8 HORIZON

```
    [ASTRO\]HORIZON h1 h2 ... [/AIRMASS] [/SOURCE ... ] [/PLANET  ...  ]
[/FLUX Fmin Fmax] [/NIGHT_MARKS] [/ALTERNATE] [/PROJECT] [/ELEVATION]

This  command  is  used to produce plots of LST ranges of observability,
above specified elevations, of sources and planets. An OBSERVATORY and a
TIME must have been selected. The LST axis is drawn on the bottom of the
plot, and UTC on the top . An horizontal line is drawn for the time  pe-
riod during which the object(s) is(are) visible above elevation h1; tick
marks and labels are provided for elevations h1, h2, ...  (in  degrees),
or  corresponding  air  masses  values (with /AIRMASS option). Elevation
values must be in increasing order, or airmasses in decreasing order.

Various options are available to control the plot:
    /SOURCE                  will plot all sources
                             of the current (by default) or alternate
                             (if /ALTERNATE is used) catalog.
    /SOURCE name1 name2 ...  will be restricted to the specified sources
                             (sources are searched for in memory
                             (after SOURCE command) or in the current
                             catalog)
    /SOURCE NEXT n           will plot the next n sources in the current
                             catalog (repeat this command to avoid over-
                             crowded pages)
    /ALTERNATE               with /SOURCE, will use the Alternate catalog
    /FLUX Fmin Fmax          restrict the search to sources with flux in
                             the specified range.
```

```
/PLANET                   will plot on one page all solar-system bodies
/PLANET name1 name2 ...   will be restricted to the specified bodies

/NIGHT_MARKS              Plots also the beginning and end of astronomica
                          nautical and civil twilights, and an estimate o
                          the moon phase and the moon bolometric magnitud
```

For specific Plateau de Bure scheduling purposes, the options /PROJECT and /ELEVATION can be used to further restrict the search of the sources in the catalog. In that case, the source catalog must have a number of additional parameters available for each source (project name, frequency, priority, minimal elavation,...).

7.1.9 OBSERVATORY

```
[ASTRO\]OBSERVATORY [longitude latitude altitude [radius]]
        or
[ASTRO\]OBSERVATORY [Name] [Version] [Mode]
```

Specify an observatory by giving its geographic coordinates in degrees, and elevation in km above sea level. Caution: east longitudes are positive. The fourth argument is the radius of the Sun avoidance circle, in degrees (default is 30 degrees).

Example: OBSERVATORY 44:23:12.0 +45:09:57.9 3.987 30.

A number of observatories are pre-defined and can be selected directly be typing "OBSERVATORY Name". Type "OBSERVATORY ?" for the list of known telescopes.

Without argument, the observatory name is translated from the GAG_ASTRO_OBS logical name.

For NOEMA, PDBI, PICO, and ALMA, a version can be added as argument. This can be used to select the instrument capabilities, as done by SELECT PDBI|ALMA command in the past.

For NOEMA, there is only one year possible for the time being (2017). In ASTRO, the switch to NOEMA observatory name has been placed at the delivery of the NOEMA backend polyfix.

For PDBI (observatory can be PDBI or BURE), a year must be entered: 1995, 2000, 2006, 2010, 2013, or 2015. They correspond to the upgrades of the receiver system (1995, 2006, and 2015) and of the correlator (2000, 2010, 2013).

For PICO, the year can be 2016 or 2021. 2021 takes into account the change in frequency coverage in 2021 (outer baseband folding frequency

```
changed)

For ALMA, the cycle number must be entered (0, 1, ...). Any number larg-
er than the current cycle is equivalent to "OBSERVATORY ALMA  FULL"  and
points to the full ALMA capabilities.

For  NOEMA, PDBI, ALMA, and 30m,  OBSERVATORY also enables some specific
commands to define and visualize receiver  and  backend  configurations.
These  commands are gathered together in the dedicated languages NOEMA\,
PDBI\, PICO\ and ALMA\ (see e.g. HELP NOEMA\ for the list  of  available
commands).
```

OBSERVATORY NOEMA

```
    OBSERVATORY NOEMA [Version] [Mode]

NOEMA  has  only 1 available version, identified as 2017. It corresponds
to the delivery of the NOEMA correlator PolyFix.

- 2017: NOEMA receivers and Polyfix Backend (1 mode)

Internal use: In the specific case of NOEMA, a mode (ONLINE|OFFLINE) can
also be given.  OFFLINE mode is the default mode, that should be used by
PIs to prepare observations.  ONLINE mode is defined  to  use  the  same
syntax as at the observatory, in OBS software (WORK IN PROGRESS).
```

OBSERVATORY PDBI

```
    OBSERVATORY PDBI [Year]

Several states of the PDBI hardware implementation can be accessed using
the year in which they were installed:

 -1995: 3 and 1.3 mm receivers, 500 MHz bandwidth
 -2000: 3 and 1.3 mm receivers, 580 MHz bandwidth
 -2006: new generation receivers (NGR: 4 GHz bandwidth, 2 polar.)
 -2010 NGR +  modifications in the LO system
 -2013 = 2010 + additional slight modification in the LO system
 -2015 = 2013 + Optimized tuning on a LO grid [default]
```

OBSERVATORY ALMA

```
    OBSERVATORY ALMA [Cycle]

For ALMA, a cycle number can be entered (0, 1, ...). Any  number  larger
than  the  current  cycle  is  equivalent to "OBSERVATORY ALMA FULL" and
```

points to the full ALMA capabilities [default].

7.1.10 PLANET

```
[ASTRO\]PLANET [name] [/DRAW [Arg1 ... ArgN]] [/QUIET] [/BEAM beam]
```

Compute the coordinates of a Solar System object. Known objects are: MOON, SUN, MERCURY, VENUS, MARS, JUPITER, SATURN, URANUS, NEPTUNE. If no name is entered, all objects are selected. The Option /DRAW is used to plot the object symbol on the screen.

The PLANET command output the planet coordinates (apparent RA, apparent DEC, Azimuth and Elevation at time of computation) and the sun distance (with a warning message if this distance os lower than the telescope limit). PLANET also indicates the geocentric (DE) and heliocentric (DS) distances of the object (in AU), the apparent minor and major diameters (Min and Maj in arcsec), the position angle of the central meridian (PA, east from north, in degrees), the brightness temperature (TB in K), the flux (S in Jy) at the current frequency, the frequency (in GHz), the beam (in arcsec), the main beam temperature (Tmb in K), the associated flux (in Jy) and the planet size convolved with the telescope beam (size in arcsec). The frequency can be entered by updating the variable FREQUENCY (in GHz). Without the option /BEAM, the beam used is deduced from the current observatory and frequency. User may override this default by giving non zero beam size (in arcsec) as an argument of the /BEAM option.

All these parameters are also also written in SIC variables, in the ASTRO%PLANET% structure. Just enter EXAMINE ASTRO%PLANET% to get a complete list of these variables. PLANET /QUIET suppresses all the printouts on the screen.

PLANET /DRAW

```
ASTRO\PLANET [...] /DRAW [Arg1 ... ArgN]
```

Arguments to PLANET /DRAW may be:

LINE
: Draw a line from the previously computed position (SOURCE or PLANET)

MARKER
: Draw a marker (GreG style defined by GREG\SET MARKER) at the computed position

SYMBOL
: Draw the planet symbol at the computed position.

FULL
: Combine MARKER and SYMBOL (the name will be offset one marker size

```
      above the computed position).
  BOX
      Draw a box around the symbol plotted by SYMBOL (suited for SYMBOL,
      not FULL).

Default is SYMBOL. If several arguments are given they will be  used  in
sequence.
```

7.1.11 SET

```
    [ASTRO\]SET parameter value

Enter a value for a parameter. Valid parameters are :
  - SET ATM VersionYear (1995, 2003 or 2009)
  - AZIMUTH   North|South
  - DUT1  Value (in seconds)
  - DTDT  Value (in seconds)
  - SET FREQUENCY MainAxis SecondAxis
  - SET LINES [ON|OFF|Profile Width]
  - SET NAME Argument
See subtopic for details
```

SET ATM

```
    [ASTRO\]SET ATM Version

Set the ATM version to be used by the ATMOSPHERE command.  Choices are:
- OLD or 1985 select the old ATM model, in use at IRAM since circa 1985.
- 2003 select the 2003 version of the ATM model, developed by Juan Pardo
  in ISM in Madrid. For this, the  corresponding  ATM  library  must  be
  available on your system.
- NEW  or 2009 select the 2009 ATM model, developed by Juan Pardo in ISM
  in Madrid. For this, the ATM library must have been compiled  together
  with Gildas (implicit if a C++ compiler was found).

Default  is  2009.  You have to switch explicitly to 1985 or 2003 if the
2009 version is not available on your system.
```

SET AZIMUTH

```
    [ASTRO\]SET AZIMUTH North|South

  Indicate where is the Zero of Azimuth. This depends on the
  Observatory.
```

SET DUT1

```
    [ASTRO\]SET DUT1  Value
```

```
Set the value of (UT1-UTC) in seconds of time for the ephemeris.
It should be taken from the IERS.
```

SET DTDT

```
    [ASTRO\]SET DTDT  Value

Set the value of (TDT-UTC) in seconds of time for the ephemeris.
It should be taken from the IERS.
```

SET FREQUENCY

```
       [ASTRO\]SET FREQUENCY [MainAxis SecondAxis]

Define the main and secondary frequency frames of  the  current  session
for  EMIR and NOEMA receiver and backend frequency coverages.  The lower
axis of the plots is always in the main frequency frame, while the upper
axis displays the secondary frame.  Possible frames are:
  REST,LSR,RF for the main frame and
  REST,LSR,RF,IF1,IF2,IMREST,IMLSR,IMRF,CHUNK,NULL  (i.e. nothing drawn)
for the secondary frame.  When CHUNK is chosen, the  chunk  numbers  are
indicated in the upper axis.

SET  FREQUENCY  DEFAULTS  comes back to the default (main='REST', second
axis='NULL').  Note that the main frequency frame defines not  only  the
lower axis of the plot but also the frame in which input and output fre-
quencies are given.

With no arguments, SET FREQUENCY displays the current content of the ax-
is.
```

SET LINES

```
    ASTRO\SET LINES ON|OFF
    or
    ASTRO\SET LINES Shape Width

Define  if  and  how molecular lines will be drawn on frequency coverage
plots (commands PICO\EMIR,BACKEND for 30m and  NOEMA\TUNING,BASEBAND,SPW
for NOEMA).

- ON|OFF: to switch ON or OFF the drawing of the lines
- BOXCAR|GAUSS|MARKER  Width: to choose the profile of the drawn molecu-
  lar lines. Marker (the default profile) is a simple vertical line. The
```

```
  width  (respectively FWHM) of the boxcar (resp. gaussian) profile must
  be provided as 3rd argument (in MHz).

The lines are taken from the line catalog that can be defined  with  the
command CATALOG /LINE.
```

SET NAME

```
    [ASTRO\]SET NAME Argument

Define  the  naming  convention  for  listing  sources from the catalog.
Sources in the catalog may have several names (see HELP CATALOG Format).
This  command define which name should be printed in commands SOURCE and
HORIZON. Argument can be
    *   to print the name of the source which has been searched for
    ALL to print all the possible names of the source
    1,2,3 etc... to print the first, second, third, etc.. possible names
    of the source
```

7.1.12 SHOW

```
    [ASTRO\]SHOW [PARAMETER]

Display  the  value  of ASTRO parameters defined by SET, OBSERVATORY and
TIME commands. Valid parameters are :

  - ATM: current version of atm
  - AZIMUTH: current 0 azimuth  (North|South)
  - DUT1:  Value (in seconds)
  - DTDT:  Value (in seconds)
  - FREQUENCY: current Main and Secondary axes for frequency plots
  - LINES: display how molecular lines are drawn on frequency plots
  - NAME: display which source name will be drawn (if multiple names)
  - OBSERVATORY: current observatory coordinates and characteristics
  - TIME: current system time (as defined by TIME command)
  - ALL: display all parameters
```

7.1.13 SOURCE

```
    [ASTRO\]SOURCE [name [...]] [/DRAW  [Arg1  ...  ArgN]]  [/ALTERNATE]
[/SUN] [/FLUX Fmin Fmax] [/RESET] [/DOPPLER] [/CURSOR]
[ASTRO\]SOURCE /VARIABLE VarName [/ALTERNATE] [/FLUX Fmin Fmax]

Compute the coordinates of a source from the current catalog (or the al-
ternate catalog, if the option /ALTERNATE is used). If no name is speci-
fied,  all  sources  of the catalog are selected. Source coordinates may
also be directly specified in the command line, in the  same  format  as
the  catalog  file.  The /DRAW option is used to draw the source name on
```

```
the plot at its current position (Azimuth, Elevation).

The source coordinates (azimuth and elevation at  time  of  computation)
are  printed  on  the screen, as well as the line-of-sight components of
the following velocities:
  - V(S/OBS)
    Source (S) relative to Observatory
  - V(S/LSR)
    Source (S) relative to Local Standard of Rest. This is the  LSR  ve-
    locity furnished by the observer as part of the source coordinates.
  - V(LSR/G)
    Local Standard of Rest relative to Solar System Barycenter (G)
  - V(G/OBS)
    Solar System Barycenter (G) relative to the Observatory
All velocities are in km/s, positive if the distance is increasing. With
the above convention,  V(S/OBS)  =  V(S/LSR)+V(LSR/G)+V(G/OBS).  Coordi-
nates, velocities, and redshift are written in SIC variables, in the AS-
TRO%SOURCE% structure (just type EXAMINE ASTRO%SOURCE% to get  the  com-
plete list).

The  output of the SOURCE command can be modified with the following op-
tions: SOURCE /SUN will also  list  the  sun  avoidance  limits;  SOURCE
/PRINT suppresses the printing of Azimuth, Elevation, and the velocities
and prints the source properties as in catalog; SOURCE /QUIET suppresses
all  printout (useful to avoid too many messages on the screen in e.g. a
loop on many sources).

SOURCE /FLUX Fmin Fmax will select only sources with flux  densities  in
the specified range. Marker sizes will be proportional to the (logarithm
of the) flux. This is useful to, e.g., filter a list of potential  cali-
brators.

SOURCE /RESET will nullify all internal source parameters and remove the
ASTRO%SOURCE%VARIABLE.
```

SOURCE /DRAW

```
    ASTRO\SOURCE [...] /DRAW [Arg1 ... ArgN]

Arguments to SOURCE /DRAW may be:
  LINE
      Draw a line from the previously computed position (SOURCE or PLAN-
      ET)
  MARKER
      Draw  a marker (GreG style defined by GREG\SET MARKER) at the com-
      puted position
  SYMBOL
      Draw the source name in capitals at the computed position.
```

```
  FULL
      Combine MARKER and SYMBOL (the name will be offset one marker size
      above the computed position).
  BOX
      Draw  a  box around the name plotted by SYMBOL (suited for SYMBOL,
      not FULL).
```

Default is SYMBOL. If several arguments are given they will be used in sequence.

SOURCE /VARIABLE

```
[ASTRO\]SOURCE /VARIABLE VarName [/ALTERNATE] [/FLUX Fmin Fmax]
```

Load (a subset of) the (alternate) source file in a user structure (the structure will be global, and created if needed). /FLUX can be used to select a range of fluxes. In return, the user structure contains:

```
  S%N                  number of lines read and selected
  S%NAME[S%N]          source name (or names, appended with |)
  S%SYSTEM[S%N]        coordinate system
  S%EQUINOX[S%N]       equinox if coordinate system is Equatorial
  S%LAMBDA[S%N]        lambda coordinate (radians)
  S%BETA[S%N]          beta coordinate (radians)
  S%VTYPE[S%N]         velocity type
  S%VELOCITY[S%N]      velocity value
  S%REDSHIFT[S%N]      redshift value
  S%ITYPE[S%N]         intensity type (FLux, MAgnitude)
  S%INTENSITY[S%N]     intensity value
  S%SPINDEX[S%N]       spectral index
  S%MAGNITUDE[9,S%N]   9 magnitudes per source (see HELP CATALOG FORMAT)
```

According to the current ASTRO\SET NAME tuning, the variable S%NAME[i] may contain one or all variant names of the source.

Note that in order to see any change in the source file(s) (new file name, updated file contents), the structure should be reloaded by calling again this command.

SOURCE /DOPPLER

```
[ASTRO\]SOURCE /DOPPLER Type Value
```

Can be used to be abe to take into account LSR velocities or redshift in the frequency coverage computations (NOEMA and PICOVELETA) without defining a full source (i.e. coordinates, V(LSR/G) and V(G/OBS) velocities are not computed. In that case V(SOU/OBS)=V(S/LSR).

```
Type can be REDSHIFT or LSR
Value is the value (real) in the corresponding type of doppler.
```

SOURCE /CURSOR

```
    [ASTRO\]SOURCE /CURSOR

Trigger  the interactive cursor on the plot. When the user clic on a po-
sition the information about the closest source  are  displayed  in  the
terminal.
```

7.1.14 TIME

```
     [ASTRO\]TIME [time [date]] [/ZONE Z] [/UT1] [/TDT] [/NODRAW]

Specify  the  time-date  of  computation. Time is normally understood as
UTC; options /UT1 and /TDT may be used to change this to UT1 or TDT. The
time  format  is  HH:MM:SS.SSS, and the date format is DD-MMM-YYYY. Time
and date may be absent or replaced by an asterisk (*), which defaults to
current system time.  Local civil time may be input instead of UTC, with
the option /ZONE z, where z is the difference in hours between  UTC  and
local civil time (use /ZONE 2 in western Europe in Summer, 1 in winter).

By  default, if the sun is visible, a Sun Avoidance Circle (see HELP OB-
SERVATORY) is plotted. It can be suppressed using  the  /NODRAW  option.
Use HEADER to examine the value of the Sun Avoidance Circle.
```

7.1.15 UV_TRACKS

```
    [ASTRO\]UV_TRACKS   station1   station2  [station3  [...]]   [/FRAME
[size]]  [/HORIZON Elmin] [/HOUR_ANGLE  Hmin  [Hmax]]  [/INTEGRATION  t]
[/STATIONS  ALL|list]  [/TABLE  [Name]]  [/WEIGHT  Mode]  [/SIZE [Size1]
[NantSize1]  [Size2] [NantSize2] ...]  [/OFFSET offset]

Plot interferometer UV coverage as  observed  with  the  interferometer.
The  default  is  for  NOEMA, but the command is more general and can be
used with any array, especially ALMA or SMA.

Station coordinates are searched for in the  file  defined  by  the  AS-
TRO_STATIONS logical variable. The default file contains NOEMA stations.
It can be customized using the SIC LOG ASTROTIONS YouFile command.

Some configuration files for NOEMA, ALMA, and SMA are  distributed  with
gildas  and  can be used as ASTRO_STATIONS files combined with UV_TRACKS
ALL to avoid typing a lot of station names (see HELP UV_TRACKS NOEMA|AL-
MA|SMA)
```

```
Stations should be referred to by a mnemonic (e.g. E003, W000 ...)  giv-
en as arguments of UV_TRACKS.  Note that with  the  contruction  of  the
NOEMA  track  extension  the mnemonic names changed from [E,N,W]+2digits
for the station number to [E,N,W]+3digits for the station  number.   Old
names are still accepted during a transition period.

The size of the antennas can be specified with the /SIZE option.

The /STATIONS option allows to use the ranks of the stations in the file
rather than the mnemonic names.

The coordinates of the most recently selected SOURCE or PLANET are  con-
sidered. The frequency of the simulated observation is read from the Sic
FREQUENCY variable (which is also set by LET FREQUENCY command).

UV_TRACKS can be used iteratively, to simulate the observations of  sev-
eral  configurations. Option /FRAME indicate the start of a new observa-
tions: if not present, configurations are being stacked on  the  current
UV  coverage.  The user may select another color pen to distringuish be-
tween the various coverages. A sketch of the interferometer described by
ASTRO_STATIONS  is  also  drawn,  and the selected stations/antennas are
highlighted.
```

UV_TRACKS NOEMA

```
    ---- Using UV_TRACKS with NOEMA configuration files ----

UV_TRACKS can be used to simulate NOEMA observations using NOEMA config-
uration files. The sequence should be:

SIC LOG astro_stations noema-10[a,c,d].cfg
UV_TRACKS all [...options...]

The  logical astro_stations must point to a configuration file of NOEMA.
They   are   distributed   with   GILDAS   and   are   called   "noe-
ma-[10,11,12][a,c,d].cfg".  Then  "uv_track all" means all stations will
be used.
```

UV_TRACKS SMA

```
    ---- Using UV_TRACKS with SMA configuration files ----

UV_TRACKS can be used to simulate SMA observations using SMA  configura-
tion files. The sequence should be:
```

```
SIC LOG astro_stations sma-CONFIG.cfg
UV_TRACKS all [...options...]

The  logical  astro_stations  must point to a configuration file of SMA.
Four configuration files are distributed with GILDAS:

sma-sub.cfg: for sub compact configuration (note that in this configuration
             the SMA cannot observe sources at elevations lower than 31.3deg
sma-com.cfg: for compact configuration
sma-ext.cfg: for extended configuration
sma-vex.cfg: for extended configuration

Then "uv_track all" means all stations in the chosen file will be used.

A catalog of all the SMA pads is also distributed with gildas. The  pads
are  identified through their numbers (1 to 26, where 25 and 26 are JCMT
and CSO positions). Any SMA configuration can be simulated with a  typi-
cal sequence of command:

OBSERVATORY SMA
SIC LOG astro_stations sma-stations.cfg
UV_TRACKS 1 4 7 9 /FRAME [...]
```

UV_TRACKS ALMA_ACA

```
    ---- Using UV_TRACKS for ALMA ----

UV_TRACKS  can  be  used to simulate ALMA observations, using the /TABLE
and /FRAME options to create tables with one or several  configurations.
To do so, the command sequence must be

OBSERVATORY alma
SIC LOG astro_stations "alma-current.cfg"
UV_TRACKS all [...options...]

The  logical  astro_stations must point to a configuration file of ALMA.
They distributed with GILDAS and the  currently  offered  configurations
are  named "alma-current-"'J'".cfg" and "aca-current.cfg" where J is the
configuration number.  All the versions of previous  ALMA  configuration
files  are  distributed  under the names "alma-cycle"'I'"-"'J'".cfg" and
"aca-cycle"'I'".cfg", where I is the cycle number.  Note that  when  the
configuration  of several cycles are identical we keep only the files of
the first cycle in which they were offered.  Then "uv_tracks all"  means
all stations will be used.

For  ACA,  it is better to enter "observatory aca" - coordinates are the
same, but this will make sure the proper antenna diameter is used in the
```

computation of shadowing.

UV_TRACKS /FRAME

[ASTRO\]UV_TRACKS ... /FRAME [size] [/HOUR_ANGLE Hmin [Hmax]] [/TABLE [Name]] [/HORIZON Elmin] [/INTEGRATION t] [/STATIONS ALL|list] [/WEIGHT Mode]

Option /FRAME [size] should be used to start a new UV coverage. It clears the plot, draws the box, and open a new table if /TABLE is present. 'size' is the maximum UV spacing plotted, in meters (default 800 m). Subsequent call to the command (without /FRAME) adds the new configurations.

UV_TRACKS /HORIZON

[ASTRO\]UV_TRACKS ... /HORIZON Elmin [/FRAME [size]] [/HOUR_ANGLE Hmin [Hmax]] [/TABLE [Name]] [/INTEGRATION t] [/STATIONS ALL|list] [/WEIGHT Mode]

Option /HORIZON specifies a minimum elevation (in degrees) for the source.

UV_TRACKS /HOUR_ANGLE

[ASTRO\]UV_TRACKS ... /HOUR_ANGLE Hmin Hmax [/FRAME [size]] [/TABLE [Name]] [/HORIZON Elmin] [/INTEGRATION t] [/STATIONS ALL|list] [/WEIGHT Mode]

Option /HOUR_ANGLE can be used to limit the hour angle coverage. Default is from source rise (above the minimum elevation) to source setup; Hmin and Hmax are in hours.

UV_TRACKS /INTEGRATION

[ASTRO\]UV_TRACKS ... /INTEGRATION Tint [/FRAME [size]] [/HOUR_ANGLE Hmin [Hmax]] [/TABLE [Name]] [/HORIZON Elmin] [/STATIONS ALL|list] [/WEIGHT Mode]

Set the time interval (Tint, in minutes) between points in the UV plane. Default is 15 minutes per point, enough for a quick look, but insufficient for proper UV coverage on long baselines. Caution: currently there may be a max of 3000 points between HA_MIN and HA_MAX).

UV_TRACKS /STATIONS

[ASTRO\]UV_TRACKS /STATIONS ALL|list [/FRAME [size]] [/HOUR_ANGLE Hmin [Hmax]] [/TABLE [Name]] [/HORIZON Elmin] [/INTEGRATION t] [/WEIGHT

Mode]

Option /STATIONS enable to access stations by their rank number in the ASTRO_STATIONS file, rather by their mnemonic. ALL means 'take all stations'. Switching between files describing interferometer stations can be done inside ASTRO by redefining the ASTRO_STATIONS logical variable using the command
SIC LOG ASTRO_STATIONS "path/to/the/desired/file"
The NOEMA stations are described in the file GAG_DATA:astro_stations.dat

UV_TRACKS /TABLE

[ASTRO\]UV_TRACKS ... /TABLE [Name [/FRAME Size]] [/HOUR_ANGLE Hmin [Hmax]] [/HORIZON Elmin] [/INTEGRATION t] [/STATIONS ALL|list] [/WEIGHT Mode]

Option /TABLE can be used to write the sampling function (UV coverage) in a UV table for further processing such as producing beams using the task UV_MAP. Name should be specified only if option /FRAME has been used, to initialize the table. Subsequent call to the UV_TRACKS command will append the new observation to this table. The visibilities written in the UV table are constant, as if a point source were observed (real part = 1, imaginary part = 0).

UV_TRACKS /WEIGHT

[ASTRO\]UV_TRACKS ... /WEIGHT Mode [JyPerK Bandwidth] /TABLE [Name [/FRAME Size]] [/HOUR_ANGLE Hmin [Hmax]] [/HORIZON Elmin] [/INTEGRATION t] [/STATIONS ALL|list]

In the output UV table, the weight is by default constant, equal to 1. This can be modified using the /WEIGHT Mode option. Mode can be UNIFORM (constant weight), AIRMASS (weight proportional to airmass^-2, i.e. to sin(elevation)^2) or FULL.

With the option /WEIGHT FULL the weights are computed from the system temperature, derived from the frequency and receiver temperature. This option requires two additional arguments to specify the antenna gain (conversion from Jy to K, about 30 for ALMA below 350 GHz, between 22 and 35, depending on the frequency for NOEMA) and the channel width (in MHz). The frequency is derived from variable FREQUENCY. If FREQUENCY is equal to FREQ_SIG, the image frequency defined by FREQ_IMA and sideband gain ration (GAIN_IMAGE) are also used as in the ATM command. Else, GAIN_IMAGE is set to zero.

UV_TRACKS /SIZE

```
    [ASTRO\]UV_TRACKS ... /SIZE Size1 [NAntSize] [Size2 NAntSize2] [...]

The size of the antennas can be customized with the /SIZE option.   With
a  single  argument all the antennas are supposed to have the same size.
Arrays with different antenna sizes can be defined using  several  pairs
of  arguments. The first argument should be a size (in m) and the second
the number of antennas of this size in the array. The sizes are  attrib-
uted to the antenna in the order they are written in the command line.

For  known  observatories (NOEMA, ALMA, ACA,...) the size of the antenna
is already known, the /SIZE option can be used to use a different size.

The size of the antenna is used to compute antenna shadowing.
```

UV_TRACKS /OFFSET

```
    [ASTRO\]UV_TRACKS ... /OFFSET Offset

The /OFFSET option is ment to deal with the limitations of observatories
using fixed delay lines. The value should be entered in m.  Does not ap-
ply to radio interferometer.
```

7.1.16 UV_DOPPLER

```
    UV_DOPPLER  Observatory  UV_TableIn [UV_TableOut [Mode]]

Compute the Doppler parameter and correct the output table for this. The
correction  can  be  applied  to the U,V lengths, or stored as a Doppler
column for further use.

 !!! HIGHLY EXPERIMENTAL - Subject to change without notice !!!
```

7.2 PICO language internal help

Contains commands dedicated to the preparation of EMIR observations.

7.2.1 Language

```
                        pico\ Language summary

    BACKEND       : Displays the frequency coverage of a given backend
    BASEBANDS     : configure the switchbox
    EMIR          : define parameters for observations with EMIR receiver
```

7.2.2 BACKEND

```
        [PICO\]BACKEND BackendName [BackendMode]

    Set  and  identifies  the frequency coverage of a Backend (BackendName =
    FTS, WILMA, or VESPA).  The coverage is displayed, and lines in the cur-
    rent line catalog are overlaid if SET LINES ON is set.  (See CATALOG and
    SET commands).

    BackendMode is only valid for FTS. Can be NARROW (50kHz  resolution)  or
    WIDE (200kHz resolution).

    For  VESPA,  the commands displays the region where units can be placed.
    Their setting and display will be implemented later.  2 Color codes:
    Grey                    : region not covered by the Backend
    Light green             : backend unit coverage
    Darker green    : region covered by another backend
```

7.2.3 EMIR

```
        [PICO\]EMIR [Ftune1 SB1 [Ftune2 SB2]]  [/ZOOM Keyword]  [/PAGEWIDTH]
    [/INFO]

    Without  arguments,  the  command  displays the available bands of EMIR.
    With the option /INFO, several informations about the receiver are list-
    ed in the terminal.

    Different ranges are colorized:
    Black           : outside the receiver bands
    Dark grey       : in the receiver bands, but not accessible with the present
    White           : in the receiver bands, accessible with the present tuning

    With  arguments,  the command defines the tuning of EMIR (up to 2 bands)
    and represents it on the global view.

    Tuning syntax:
    Ftune1,2        : Frequency (GHz) of the first (second) band to tune
```

```
SB1,2          : IF baseband where to place Frest1,2 (used to define LO fre

Ftune1,2 must be in the current frequency main axis  (REST  by  default,
but  can  be changed with SET FREQUENCY command). If a source was previ-
ously defined, its velocity or redshift is taken into account to convert
Ftune1,2 to RF frequencies.
```

EMIR /PAGEWIDTH

```
[PICO\]EMIR [...] [/PAGEWIDTH]

When  several receiver bands are plotted, this option forces their width
to match the plot page. The consequence is that the different bands  are
displayed with different scaling in GHz/cm.
```

EMIR /ZOOM

```
[PICO\]EMIR [...] /ZOOM [Keyword] [Fmin Fmax]

Different zooming modes are implemented according to the entered Keyword
and the number of tuned bands.

ID             : Displays all the EMIR bands, the current tuning(s) is(are)
BOTH           : When two bands are tuned they are plotted without the unus
1,2            : Focus on the first or second tuning, with zoom on the two

If a frequency range Fmin Fmax (in GHz) is given instead of  a  keyword,
zoom on this range.
```

7.2.4 BASEBANDS

```
    [PICO\]BASEBANDS [Code1 Code2 Code3 Code4] [/SINGLEPOLAR]

After  a  EMIR tuning (one or more bands), defines what are the spectral
ranges that are sent to the Backends through the 8 available IF cables.

On the plot, the selected basebands are identified with their name  (see
below).   Baseband  which  will  not be brought towards the backends are
filled in light grey. If the current plot corresponds to the result of a
tuning, the plot is not redrawn.  Otherwise the current plot is redrawn.

Without  arguments, an automatic selection is performed.  When more than
one receiver band are tuned, the default maximises the coverage  of  the
FTS units and selects dual polarization when possible (losing a sideband
in each receiver band).
```

```
With the option /SINGLEPOLAR, the coverage of the FTS is still  maximum,
but  only one polarization is selected in order to process the two side-
bands in both receiver bands.

When codes are given, then the selection is up to the user.  This  might
be  needed  to send OUTER basebands towards WILMA and VESPA backends.  4
codes as inputs are required to set the content of the IF cables 1 to 4.
The  content  of IF cables 5 to 8 is not flexible and is the outer base-
band of the Receiver/Sideband/Polarization combination chosen for cables
1 to 4).

The format of the Code is: BBPSB
BandName (2 characters) : BB = E0, E1, E2 or E3 for EMIR
                          bands E090, E150, E230 or E350
Polar    (1 character)  : P = H or V
Sideband (1 character)  : S = U or L
Baseband (1 character)  : B = I or O
```

BASEBANDS /SINGLEPOLAR

```
    [PICO\]BASEBANDS [Code1 Code2 Code3 Code4] /SINGLEPOLAR

This option may be needed when 2 receivers are used simultaneously.
With the option /SINGLEPOLAR, the coverage of the FTS is still
maximum, but only one polarization is selected in order to process the
two sidebands in both receiver bands.
```

7.3 NOEMA languages internal help

7.3.1 OFFLINE MODE

Contains commands dedicated to the preparation of NOEMA observations after the delivery of PolyFix correlator.

7.3.2 NOEMAOFFLINE\

```
                        NOEMAOFFLINE\ Language summary

    BASEBANDS : Select basebands (4GHz wide) and assign them a correlator mode
    LIST      : Lists the defined spectral windows
    NEWVEL    : Compare SPW coverage for different sources (ment to be used by S
    PLOT      : Plot the current state of the receiver and backend setup
    PROPOSAL  : Write a sequence of ASTRO commands to define the receiver/backen
    RESET     : Remove spectral windows
    SETUP     : Write a sequence of OBS commands to define the receiver/backend
    SPW       : Configure and plot the backend units
    SPECSWEEP : Tool to prepare multiple tuning for optimized spectral coverage
    TSYS      : Create the NOEMA Tsys table
    TUNING    : Define and plot the frequency coverage of NOEMA receivers
```

7.3.3 BASEBANDS

```
        [NOEMAOFFLINE\]  BASEBANDS  [SelectionCode]  [/MODE [df1 [df2]]|OFF]
    [/RESET]

    After a receiver TUNING, select a number of 4GHz  basebands  and  assign
    them  a  correlator mode. Forthcoming SPW commands will concern only the
    selected basebands.  The selection is done  through  0  to  5  character
    codes  to  indicate  the band (2 characters), polarization, sideband and
    baseband (1 character each). Any of these elements  can  be  omitted  to
    make  no  particular selection on the corresponding, but if present, the
    above order must be preserved.

    Examples:
    BASEBAND        : will select all the basebands
    BASEBAND B1HUO  : will select only the outer baseband of the upper
                      sideband in polar H for the Band 1 tuning.
                      (Band is not mandatory when only 1 receiver band is tuned)

    The correlator mode selection is done using the /MODE option.
```

BASEBANDS /MODE

```
[NOEMAOFFLINE\]BASEBANDS [SelectionCode] /MODE df1 [df2]

Define the correlator mode to be used for the  selected  basebands.  The
mode selection is done by giving the channel spacing value(s) in kHz:

2000 62.5 = Full baseband at 2MHz channel spacing + 16 HighRes Chunks (62.5k
250       = Full baseband at 250kHz channel spacing

If  the  keyword  OFF is entered instead of the channel spacing, then no
correlator mode is assigned to the selected baseband(s), they  will  not
be used.
```

BASEBANDS /RESET

```
[NOEMAOFFLINE\]BASEBANDS [SelectionCode] /RESET

Reset  the configuration of the correlator for the selected baseband. If
High Resolution spectral windows were defined, they will be removed.  If
combined  with  /MODE the current setup is reset and the new mode is ap-
plied.
```

7.3.4 LIST

```
[NOEMAOFFLINE\]LIST [Spw1 Spw2] [/CONFLICT] [/INDEX]

List the defined spectral windows. If present Spw1 and Spw2  define  the
range  of listed spectral windows.  They are sorted according to resolu-
tion (low resolution first), then RF frequency and finally  polarization
(order different from the index one, which follows the true order at the
observatory)
```

LIST /CONFLICT

```
[NOEMAOFFLINE\]LIST [/CONFLICT]

The list contains only the spectral windows in conflict (i.e. when  sev-
eral  SPW use the same chunk, or when more chunks than possible are con-
figured).
```

LIST /INDEX

```
[NOEMAOFFLINE\]LIST [/INDEX]
```

The displayed list is ordered according to their index (resolution - low resolution first, polarization - H first, then frequency).

7.3.5 NEWVEL

```
[NOEMAOFFLINE\]NEWVEL VType Value [Tolerance] [/FIXEDEQ] [/SETUP]
```

Applies the current backend configuration to a source at different LSR velocity or redshift to compare the frequency coverage of high resolution spectral windows. With Vtype LSR (resp. REDSHIFT), Value should be the LSR velocity in km/s (resp. the redshift) for which the comparison is desired. The shift in REST frequency coverage between the two sources is computed and compared to a tolerance (in MHz) that can be given as third argument (0 is the default value).

With the option /FIXEDEQ, the tuning for the new redshift or velocity will not be adapted to match the optimized tuning grid (as a result, the frequency coverage offset is null)

NEWVEL /SETUP

```
[NOEMAOFFLINE\]NEWVEL VType Value [Tolerance] /SETUP LineName RepFreq
[Resolution] [/LINES]
```

The \SETUP option is used as output the commands in ONLINE syntax that are needed to configure the system as they should appear in the observing setup file. It is ment to be used by the Setup Management System when preparing the observing procedures of accepted proposals. If the shift between the coverages at the two considered LSR velocities or Redshift is larger than the tolerance, then the ONLINE commands are not printed.

/SETUP option requires at least 2 arguments: the line name as it will appear in the NOEMAONLINE\LINE command, and the representative frequency of the setup (see Proposal Management System), in GHz. The desired spectral resolution (in kHz) can be given as third argument. Some information about the frequency coverage (e.g. number of polarization covering the representative frequency, USB and LSB coverage limits, continuum bandwidth,...) is given in output.

The option /LINES can be used to display the catalog lines.

NEWVEL /TRACKSH

```
[NOEMAOFFLINE\]NEWVEL VType Value [Tolerance] /TRACKSH Min Max
```

```
With this option, the frequency plot will show  how  the  lines  in  the
sources with Min and Max velocity (or redshift) will be shifted with re-
spect to the doppler tracked frequency (defined by Value).  This  option
is ment to be used by SMS in case of track sharing projects, where Value
will be the mean velocity.
```

7.3.6 PLOT

```
[NOEMAOFFLINE\]PLOT [SelectionCode]

Displays the current state of the receiver and backend configuration.  A
warning message is added to the plot when the current setup is not tech-
nically feasible (chunk conflicts or unit overload).

With no arguments all the basebands are plotted.  A subset of  basebands
can  be  selected using a character code to indicate the band (2 charac-
ters), polarization, sideband and baseband (1 character  each).  Any  of
these  elements  can  be  omitted to make no particular selection on the
corresponding, but if present, the above order must be preserved.

Examples:
PLOT : will plot all the basebands
PLOT B1HUO  : will plot only the outer baseband of the upper
                  sideband in polar H for the Band 1 tuning.
                  (Band is not mandatory when only 1 receiver band is tuned)
```

PLOT /RECEIVER

```
[NOEMAOFFLINE\]PLOT [/RECEIVER]

Plot the current receiver and backend setup on a plot  where  the  whole
receiver band is drawn at the center of the page with a zoom to the Low-
er Side Band below it and a zoom to the Upper Side Band above.
```

PLOT /PROPOSAL

```
[NOEMAOFFLINE\]PLOT [/PROPOSAL [Frequency] [/LINES]]

This option is meant to be used through PMS to create very simple summa-
ry plots.

Plot the current receiver and backend configuration in a single horizon-
tal plot. By default spectral lines from the  current  catalog  are  not
drawn.  This  can be changed using the /LINES option (global behavior as
```

```
defined by SET LINES is not affected).

A representative frequency [GHz] can be indicated  as  argument  of  the
/PROPOSAL option. It will be indicated on the plot and the number of po-
larizations covering this frequency (in all spectral resolution) is com-
puted.  In addition a channel spacing [kHz] can be given as second argu-
ment. In that case the number of polarizations covering the  representa-
tive frequency at the indicated channel spacing is also given.
```

7.3.7 PROPOSAL

```
[NOEMAOFFLINE\]PROPOSAL [/FILE file.ext] [/TIME]

Write  (to  screen or in a file defined with /FILE option) a sequence of
commands to come back to the current state of  receiver/backend  defini-
tions.  The  commands  are written in the language NOEMAOFFLINE, and the
output script can be updated to the Proposal Management System during  a
proposal preparation session.

PROPOSAL  will  return  an error if the configuration is not technically
feasible (chunk selected by more than 1 spectral window, or more  chunks
needed than available in a correlator unit).

With  the  option /TIME, the time used for the computation of source ve-
locities will be added in the output script.

In addition to the commands, the output of  PROPOSAL  contains  all  the
spectral lines of the current catalog which fall in the observed ranges.

The  command SETUP creates a similar script, but in the NOEMAONLINE lan-
guage (OBS syntax).
```

7.3.8 RESET

```
    [NOEMAOFFLINE\]RESET [LAST|*|SpwList]

Reset spectral windows. Free the corresponding chunks of the correspond-
ing correlator unit.
-RESET = RESET LAST: reset the spectral windows created by the last SPW comm
-RESET *: reset all the flexible spectral windows.
-RESET SpwList: rest a list of SPW (SIC list format).
                SPW are identified through their index as seen in LIST
```

7.3.9 SETUP

```
    [NOEMAOFFLINE\]SETUP [/FILE OutFile]

Write  (to  screen or in a file defined with /FILE option) a sequence of
```

commands to come back to the current state of receiver/backend definitions. The commands are written in the language used at the observatory to define the receiver and correlator setups. This can be run in ASTRO after switching to NOEMA online mode: OBSERVATORY NOEMA ONLINE

SETUP will return an error if the setup is not technically feasible (chunk selected by more than 1 spectral window, ore more chunks needed than available in a correlator unit).

The output commands are compatible with the online software at the NOEMA observatory. In detail SETUP will convert the rest frequency to LSR frequency for sources defined with a redshift and enter the source command with "LSR 0" instead of "RED zz.z".

In addition to the commands, the output of SETUP contains all the spectral lines of the current catalog which fall in the observed ranges.

7.3.10 SPW

[NOEMAOFFLINE\]SPW [/RANGE Fmin Fmax] [/FREQUENCY Fcent dF] [/CHUNK ChunkList] [/LABEL Label]

Configure and visualize flexible spectral windows in Polyfix units. A receiver tuning must have been defined (RECEIVER command) and at least a baseband must have been selected (BASEBAND command). SPW can be used only on Basebands defined with a correlator mode allowing for the configuration of high resolution spectral windows. A typical sequence can be:

```
TUNING 230 LSB 7777    : Define the receiver tuning
BASEBANDS 62.5 HUO     : Select a baseband and assign a correlator mode
SPW /RANGE 227 227.3   : Configure and plot 1 spectral window
                          (from <~227 to ~>227.3 GHz)
SPW /FREQUENCY 228 0.2 : Configure and plot a second spectral window
                          of ~>200MHz around 228 GHz)
SPW /CHUNK 6  30 to 40 : Configure 2 new spectral windows
```

The frequency inputs with /RANGE and /FREQUENCY options have to be given in the current main frequency axis as defined with the SET FREQUENCY command (REST by default).

Once configured, the spectral windows are ordered by resolution then frequency then polarization. The configured spectral windows can be listed with the LIST command. The RESET command can be used to remove a spectral window.

```
Feasibility of the setup: SPW returns warnings if the current definition
of spectral windows is not technically feasible (i.e. if a chunk is used
by more than 1 spectral window or if the spectral windows in a  correla-
tor  unit  require  more chunks than available). The warnings have to be
removed in order to be able to create an observing  script  (SETUP  com-
mand,  not yet implemented) or to make a summary plot of the setup (PLOT
command).
```

SPW /RANGE

```
[NOEMAOFFLINE\]SPW /RANGE Fmin Fmax

Define a spectral window from Fmin to Fmax (GHz) in the current frequen-
cy frame (as defined with SET FREQUENCY command).  Fmin and Fmax must be
in the same baseband.
```

SPW /FREQUENCY

```
[NOEMAOFFLINE\]SPW /FREQUENCY Fcent dF

Define a spectral window from Fmin=Fcent-dF/2 to Famx=Fcent+dF/2 in  the
current  frequency frame (as defined with SET FREQUENCY command).  Fcent
and dF must be in GHz.  Fmin and Fmax must be in the same baseband.
```

SPW /CHUNK

```
[NOEMAOFFLINE\]SPW /CHUNK ChunkList

Define spectral windows by defining directly the chunks to  be  used  by
their numbers. This mode is available only when a single Baseband (even-
tually in dual polarization) is selected with the BASEBAND command.

The ChunkList follows the SIC\FOR list format. For example:
  SPW /CHUNK  1  5  10 TO 12
will add 3 more spectral windows:
- one new spw with the chunk #1,
- one new spw with the chunk #5,
- one new spw with the chunks #10, 11, and 12.
```

SPW /LABEL

```
[NOEMAOFFLINE\]SPW [...] /LABEL Label

With the option /LABEL, a name can be attached to the  defined  spectral
windows.
```

7.3.11 SPECSWEEP

[NOEMAOFFLINE\]SPECSWEEP ChannelSpacing [/RANGE Fmin Fmax [/BAND-MAX]] [/NTUNING n Freq Align] [/ZOOM RANGE|RECEIVER] [/FILE 'basename']

Tool to find receiver tunings in order to prepare large frequency coverage projects.

The command argument is the Channel Spacing at which the observations will be performed. The correlator mode to be used will be defined accordingly.

With option /RANGE the command proposes a combination of tunings that cover at least the specidified range. See help SPECSWEEP /RANGE.

With option /NTUNING the users specifies the number of tuning he wants to use together with a frequency and an alignement code in order to place the tunings

The option /ZOOM can be used to select the frequency limits of the plot: whole receiver band or covered frequency range only.

With the option /FILE name, the command will create as many astro scripts as tunings defined by the command. They will be named name-[1-n].astro. They can be entered individually entered in the Proposal Management System to tranfer them into a proposal.

SPECSWEEP /RANGE

[NOEMAOFFLINE\]SPECSWEEP ChannelSpacing [/RANGE Fmin Fmax [/BANDMAX]]

Fmin and Fmax (in GHz) are the limits of the required observations. The option /BANDMAX allows to chose between tuning overlap or extended coverage when placing the tuning in the band.

SPECSWEEP /NTUNING

[NOEMAOFFLINE\]SPECSWEEP ChannelSpacing [/NTUNING n Freq Align]

n is the number of tuning required by the user. The Align code (MIN|CENTER|MAX) will define if the entered Freq (GHz) has to be placed at the center or at one edge of the final coverage.

7.3.12 TSYS

```
    [NOEMAOFFLINE\]TSYS TableName

Create the Tsys binary table used by the  NOEMA  sensitivity  estimator.
None of the inputs can be customized at user level. Contents are:

Code      C*4  [     ]  System code

Pressure  R*4  [HPa  ]  Pressure at observatory altitude
Gaini     R*4  [     ]  Image band gain
IF        R*4  [GHZ  ]  Intermediate frequency

Nf        I*4  [     ]  Number of frequencies
Na        I*4  [     ]  Number of airmasses
Nw        I*4  [     ]  Number of precipitable water vapor amounts
Nt        I*4  [     ]  Number of temperatures

F[Nf]     R*4  [GHz  ]  Frequencies
A[Na]     R*4  [Neper]  Airmasses
W[Nw]     R*4  [mm   ]  Precipitable water vapor amounts
T[Nt]     R*4  [K    ]  Temperature values
Trec[Nf]  R*4  [K    ]  Receiver temperatures (per frequency)
Feff[Nf]  R*4  [     ]  Forward efficiencies (per frequency)

Tsys[Nf,Na,Nw,Nt]  R*4  [K    ]  Tsys
```

TSYS /CONTINUUM

```
Create  the binary table of CONTINUUM Tsys used by the NOEMA sensitivity
estimator. None of the inputs can be customized at user level.  Contents
are:

Code      C*4  [     ]  System code

Pressure  R*4  [HPa  ]  Pressure at observatory altitude
Gaini     R*4  [     ]  Image band gain

Ne        I*4  [     ]  Number of elements (should be 3 = min,aver,max)
Nf        I*4  [     ]  Number of LO frequencies
Na        I*4  [     ]  Number of airmasses
Nw        I*4  [     ]  Number of precipitable water vapor amounts
Nt        I*4  [     ]  Number of temperatures

F[Nf]     R*4  [GHz  ]  LO Frequencies
A[Na]     R*4  [Neper]  Airmasses
W[Nw]     R*4  [mm   ]  Precipitable water vapor amounts
```

```
T[Nt]     R*4  [K    ]  Temperature values
Trec[Nf]  R*4  [K    ]  Receiver temperatures (per LO frequency)
Feff[Nf]  R*4  [     ]  Forward efficiencies (per LO frequency)

Tsys[Ne,Nf,Na,Nw,Nt]  R*4  [K    ]  Tsys

In  its  first dimensions, the Tsys table provides the triplet of values
[min, average, max] found from the two sidebands  around  the  given  LO
frequency.
```

7.3.13 TUNING

```
    [NOEMAOFFLINE\]TUNING  [Ftune(GHz)  Sideband  FIF(MHz)]  [/ZOOM Key-
word] [/PAGEWIDTH] [/INFO] [/FIXED_FREQ]

Without arguments, the command displays the available bands of NOEMA Re-
ceivers.   With the option /INFO several informations about the receiver
are displayed in the terminal.

Different ranges are colorized:
Black           : outside the receiver bands
Dark grey       : in the receiver bands, but not accessible with the present
White           : in the receiver bands, accessible with the present tuning

With arguments, the command defines the tuning of one of  the  band  and
represents it on the global view.

Tuning syntax:
Ftune   : Frequency to tune (in GHz)
SideBand: Sideband where to place Ftune (LSB or USB)
FIF     : Position where Ftune will be placed in the IF band (in MHz)

Ftune  must  be in the current frequency main axis (REST by default, but
can be changed with SET FREQUENCY command)

If a source has been defined, its velocity (or redshift) is  taken  into
account to convert Ftune to RF frequency.

NOEMA  observations  are preferentially performed using a limited number
of LO frequencies for which receiver performances have  been  optimized.
Those  frequencies  are  distributed  all  over the receiver bands every
500MHz (the so-called  tuning  grid).  The  NOEMAOFFLINE\TUNING  command
takes  this  into  account  and  shifts  the  IF center frequency FIF if
necesssary so that the LO tuning frequency matches the tuning grid.

The tuning frequency is computed using only  the  source  LSR  velocity.
With  the Doppler tracking, the actual LO is slightly different from the
tuning frequency.  Both tuned and tracked LO frequencies  are  given  in
```

output. With the option /FIXED_FREQ, the command ignores the tuning grid.

TUNING /PAGEWIDTH

```
[NOEMAOFFLINE\]TUNING [...] [/PAGEWIDTH]
```

When several receiver bands are plotted, this option forces their width to match the plot page. The consequence is that the different bands are displayed with different scaling in GHz/cm.

TUNING /FIXED_FREQ

```
[NOEMAOFFLINE\]TUNING Ftune SideBand FIF /FIXED_FREQ
```

With this option, the command ignores the tuning grid: the input FIF is used even if the corresponding LO frequency is not on the optimized tuning grid.

TUNING /ZOOM

```
[NOEMAOFFLINE\]TUNING [...] /ZOOM [Keyword] [Fmin Fmax]
```

Different zooming modes are implemented according to the entered Keyword and the number of tuned bands. Without /ZOOM option, all the NOEMA receiver bands are plotted, and the tuning is identified (white area) With the option /ZOOM and no argument, focus on the tuning, with zoom on the two sidebands. If a frequency range Fmin Fmax (in GHz) is given as argument, zoom on this range.

7.3.14 ONLINE MODE

Internal use only

Contains commands to mimmic OBS session inside ASTRO in order to prepare/check observing procedures or tests

7.3.15 NOEMAONLINE\

```
                        NOEMAONLINE\ Language summary

    BASEBANDS : Assign a correlator mode to a given baseband
    LINE      : Define and plot the frequency coverage of NOEMA receivers
    PROPOSAL  : Write a sequence of NEOMAOFFLINE commands to define the present
    SHOW      : Lists information about BASEBANDS or SPW
    SPW       : Configure and plot the backend units
```

7.3.16 BASEBANDS

```
        [NOEMAONLINE\] BASEBANDS [SelectionCode] [Mode] [/RECEIVER Irec]

    Assign  a  mode  to a given baseband and switch it on.  Correlator modes
    are called using their implementation number. Mode 1 offers 64 low reso-
    lution  chunks  and  up to 16 high resolution chunks in a baseband; High
    resolution chunks are selected with the SPW command.  Mode 2  offers  64
    chunks with a channel spacing of 250kHz; SPW cannot be used on basebands
    using Mode 2.  Mode can also be OFF to switch the corresponding correla-
    tor unit OFF.

    The selection is done through 0 to 3 character codes to indicate the po-
    larization, sideband and baseband (1 character each).

    Example:
    BASEBAND HUO 1 /RECEIVER 1: will set the mode 1 to the outer baseband of the
                                sideband in polar H, for the Band 1 tuning.

    Option /RECEIVER can be omitted in ASTRO as long as multi  band  is  not
    supported.
```

7.3.17 LINE

```
        [NOEMA\]LINE  Name Ftune(GHz) Sideband FIF(MHz) [/RECEIVER Irec]

    Defines the tuning of one of a receiver band

    Tuning syntax:
    Name    : Line Name
    Ftune   : Frequency to tune (in GHz)
```

```
SideBand: Sideband where to place Ftune (LSB or USB)
FIF     : Position where Ftune will be placed in the IF band (in MHz)
```

Ftune must be in REST frequency

If a source has been defined, its velocity (but NO redshift) at the current ASTRO time is taken into account to convert Ftune to RF frequency.

Option /RECEIVER can be omitted in ASTRO as long as multi band is not supported.

7.3.18 PROPOSAL

```
[NOEMAONLINE\]PROPOSAL [/FILE file.ext]
```

Write (to screen or in a file defined with /FILE option) a sequence of commands to come back to the current state of receiver/backend definitions. The commands are written in the language NOEMAOFFLINE, since the scripts are ment to be updated to the Proposal Management System during a proposal preparation session.

This can be run in ASTRO after switching to NOEMA offline mode, using the command OBSERVATORY NOEMA OFFLINE

PROPOSAL will return an error if the configuration is not technically feasible (chunk selected by more than 1 spectral window, or more chunks needed than available in a correlator unit).

In addition to the commands, the output of PROPOSAL contains all the spectral lines of the current catalog which fall in the observed ranges.

7.3.19 SHOW

```
[NOEMAONLINE\]SHOW SPW|BASEBANDS  [/PLOT]
```

List information about SPW or BASEBANDS

/PLOT option can be used to get a summary plot of the receiver/correlator configuration

7.3.20 SPW

```
    [NOEMA\]SPW  /CHUNK ChunkList /BASEBAND  BaseCode  [/RECEIVER  Irec]
[/LABEL Label]
```

Configure spectral windows in Polyfix units. SPW will work only on basebands defined with a correlator mode in which high resolution spectral

```
windows can be configured (currently only Mode 1).

  SPW /CHUNK  1  5  10 TO 12 /BASEBAND HUO
will add 3 more spectral windows in baseband HUO:
- one new spw with the chunk #1,
- one new spw with the chunk #5,
- one new spw with the chunks #10, 11, and 12.

/RECEIVER  option can be omitted as long as ASTRO does not support multi
band settings
```

SPW /LABEL

```
[NOEMA\]SPW [...] /LABEL Label

With the option /LABEL, a name can be attached to the  defined  spectral
windows.
```

7.4 PDBI and ALMA language internal help

The PDBI and ALMA languages partially share the same commands (in particular PLOT). The commands are grouped here in the same section.

7.4.1 PDBI\

```
                        PDBI\ Language summary

LINE          : define receiver setup
NARROW_INPUT  : define the input of the narrow-band correlator
PLOT          : plot the resulting frequency coverage
PRINT         : print the corresponding observing procedure
SPECTRAL      : define the configuration of the spectral units of
                 the narrow-band correlator
WIDEX         : reserved for future use...
```

7.4.2 ALMA\

```
                        ALMA\ Language summary

BASEBAND      : define position of correlator basebands (ALMA)
FREQUENCY     : define receiver setup (ALMA)
PLOT          : plot the resulting frequency coverage (PdBI, 30-m and ALMA)
SPWINDOW      : define spectral windows (ALMA)
```

7.4.3 BASEBAND

```
[ALMA\] BASEBAND i frequency [sideband]

The  ALMA  correlator  is composed of four quadrants, each of them being
able to process 2 GHz (x 2 polarization) of the receiver output. This is
called a baseband, and this 2 GHz slice can be placed at any position in
the receiver bandwidth. The BASEBAND command is used to define the  i-th
baseband, by selecting the frequency of its center. This can be done ei-
ther in the RF or the IF domains
  - if the frequency is < 1000, it is interpreted as a rest frequency
    in GHz.
  - if the frequency is > 4000, it is interpresteded as an intermediate
    frequency in MHz; a second parameter giving the sideband (LSB/USB)
    is then necessary.

Example: Receiver band 7 is tuned at 220 GHz LSB (with command
FREQUENCY). It outputs 4-8 GHz
signals in USB (corresponding to 234 to 238 GHz) and LSB (218 to 222
```

```
GHz). Baseband 1 can e.g. be placed at IF = 6.2 GHz in LSB, which
corresponds to 220.8 GHz. The commands "BASEBAND 1 220.8" and
"BASEBAND 1 6200 LSB" are therefore equivalent.

Entering "BASEBAND i" with no further arguments calls an interactive
mode in which the baseband is defined with the cursor on the plot
produced by the FREQUENCY command. Clicking in the plot defines the
frequency/sideband of the center of the baseband. Basebands are
automatically shifted to be fully included within the IF band.

The command "BASEBAND" alone enters a loop to interatively
define all four basebands (it is equivalent to FOR I 1 TO 4;
BASE I; NEXT).
```

7.4.4 FREQUENCY

```
[ALMA\]FREQUENCY Name Frequency Band Center

Define and plot the receiver frequency coverage of ALMA. The command
syntax is similar to that of the LINE command for the Plateau de Bure:
  Name      is a line name to label the plot
  Frequency is the rest frequency in GHz
  Band      should be USB or LSB
  Center    is the IF1 frequency in MHz [optional]

The command produces a plot of the USB and LSB  frequency  band.  It  is
then  necessary  to define the position of the four correlator basebands
(command BASEBAND) and then the spectral windows within  each  basebands
(command SPWINDOW).

A typical session to define an ALMA setup would be:
freq something 220 lsb ! define receiver tuning
base 1 220.8           ! define baseband #1
plot base 1            ! plot baseband #1
spw 1                  ! define spectral windows on baseband 1
                       !   using the cursor
```

7.4.5 LINE

```
    [PDBI\]LINE Name Frequency Band [Lock [Center [Harm]]]

Define  and  plot the receiver frequency coverage of the Plateau de Bure
Interferometer (with the receivers installed in winter 2006/2007).   The
command syntax is identical to that of the corresponding command in OBS:
    Name      is a line name to label the plot
```

```
    Frequency is the rest frequency in GHz
    Band      should be USB or LSB
    Lock      is LOW or HIGH [optional, default LOW]
    Center    is the IF1 frequency in MHz [optional, default 6500]
    Harm      is the harmonic number [optional]

o  The receiver band to be used (1 to 4) will be determined by the soft-
ware.

o Since 2015, NOEMA observations are preferentially  performed  using  a
limited  number  of  LO frequencies for which receiver performances have
been optimized. Those frequencies are distributed all over the  receiver
bands  every  500MHz. For latest states of NOEMA (from 2015 on), this is
taken into account in the ASTRO\LINE command. The  command  checks  that
the LO frequency is located on this grid. When this is not the case, the
command returns an error and a new IF center frequency  is  proposed  to
ensure a tuning frequency that matches the grid.  The option /ONGRID can
be used in order to let the command use  this  suggested  frequency  and
avoid  to  return an error.  The tuning frequency is computed using only
the source LSR velocity. With the Doppler tracking,  the  actual  LO  is
slightly different from the tuning frequency.  Both tuned and tracked LO
frequencies are given in output when the LINE  command  arguments  match
the  tuning  grid.  With the option /FIXED_FREQ, the command ignores the
tuning grid.

o The center frequency is expressed in the first IF (4-8 GHz = 4000-8000
MHz). WARNING: it is highly not recommended to center the line frequency
at 6 GHz. This is because the correlator analyses quarters of the 4  GHz
bandwidths,  and  6  GHz is very precisely at the limit between two such
adjacents quarters.

o The plot displays the four "quarters" Q1...Q4 that can be selected  as
input for the correlator (see NARROW_INPUT command):
  Q1 = 4.2-5.2 GHz, Q2 = 5.0-6.0 GHz
  Q3 = 6.0-7.0 GHz, Q4 = 6.8-7.8 GHz

o  Commands  NARROW and SPECTRAL are available to setup the IF processor
and the spectral units of the narrow-band  correlator  (see  the  corre-
sponding help). A typical ASTRO session would look like:

line toto 100 usb           ! choice of rx tuning
narrow q1 q3                ! choice of the correlator windows
spectral 1  20 320 /nar 1   ! correlator unit 1
spectral 2 320 200 /nar 2   ! correlator unit 2
spectral 2 320 210 /nar 2   ! new def. of unit 2 --> plot is updated

o  Command  PLOT can be used to plot the full receiver coverage, that of
```

```
the NARROW band correlator, or that or the WIDEX correlator.

o LINE can also be used to produce plots of the  frequency  coverage  of
the  old receivers (replaced in 2006/2007). The command OBSERVATORY PDBI
year allows one to select the instrument as of the selected year:
- 1995: 3 and 1.3 mm receivers, 500 MHz bandwidth
- 2000: 3 and 1.3 mm receivers, 580 MHz bandwidth
- 2006: new generation receivers (NGR: 4 GHz bandwidth, 2 polar.)
- 2010 NGR +  modifications in the LO system
- 2013 = 2010 + additional slight modification in the LO system
- 2015 = 2013 + Optimized tuning on a LO grid [default]
For the OLD receivers (years 1995 & 2000), the  commands  NARROW,  SPEC-
TRAL,  PLOT are not active. Please enter HELP LINE OLD for a description
of the behaviour of the LINE command in that case.
```

LINE /FIXED_FREQ

```
[PDBI\]LINE Name Frequency Band [Lock [Center [Harm]]] [/FIXED_FREQ]

For pdbi_year 2015, this option allows to plot  the  frequency  coverage
without  checking  that the LO frequency is on the grid of tuning (every
500MHz in LO)
```

LINE /ONGRID

```
[PDBI\]LINE Name Frequency Band [Lock [Center [Harm]]] [/ONGRID]

For pdbi_year 2015, this option let ASTRO adapt the Center IF  frequency
so  that  the  LO frequency falls on the grid of optimized tuning (every
500 MHz) in LO.
```

LINE OLD

```
    [PDBI\]LINE Name Frequency Band [Lock [Center  [Harm]]]  [/MOLECULES
File] [/SPECTRAL Unit Bandwidth IF_2] /WIDTH width
    [PDBI\]LINE /SPECTRAL Unit Bandwidth IF_2
    [PDBI\]LINE /AUTO

Plot rest frequency coverage of Plateau de Bure Interferometer using the
OLD receiver system (replaced in  2006/2007).   The  command  syntax  is
identical to that of the corresponding command in OBS.
```

```
    Name is a line name to label the plot
    Frequency is the center frequency in GHz
    Band should be USB or LSB
    Lock (optional) is LOW or HIGH
    Center (optional), the center IF2 frequency in MHz, default 350.
    Harm (optional), the harmonic number.
The  option  /MOLECULES  enables to plot the rest frequencies of several
transitions, found in file File. This is a text file with entries:
    Freq    'chain'
    where Freq is the rest frequency in GHz and 'chain' the line name to
    be plotted by GreG, between single quotes. Example:
    88.632  'HCN'
    89.081  'HCO\u+'
The  option  /WIDTH  width is used to introduce a finite width (in km/s)
for the molecular lines displayed.

The option /SPECTRAL is used to overlay the desired spectral  correlator
configuration.
    Unit is the correlator unit number (1 to 8)
    Bandwidth is the bandwidth in MHz (20, 40, 80 or 160)
    IF_2  is  the center frequency (in MHz) of the unit in the second IF
    (in the range 110 to 590 MHz).

With only the /SPECTRAL option, the corresponding unit overlay  will  be
drawn on an existing LINE plot.

Because  only  one  synthesizer is used to generate the 1st and 2nd LOs,
the IF frequency is slightly variable (between 1.500 and 1.550 GHz), and
the  Doppler  tracking  is  correct  only for the specified band (USB or
LSB).  The last specified source is used to get the Doppler shift.   The
image  frequency doppler shift is wrong by at most 2.Ers/Harm, where Ers
is the Earth rotation speed, or about 0.9 km/s, roughly 0.04 km/s at  86
GHz.

The option /AUTO is used to guess the line frequencies and spectral set-
up for Bure, given a set of variables:
N_LINE     int  number of line frequencies
N_CONT     int  number of continuum frequencies
for each of N_LINE:
LINENAME_i char line name of line table
LINEVELO_i char velocity range (2 values: min, max  in km/s)
LINEFREQ_i dble line frequency (MHz)
LINEVRES_i dble velocity resolution (km/s)
for each of N_CONT:
CONTTABLE_i char  name of continuum  table
CONTBANDS_i char  range of frequency bands for the continuum
                  (min1 max1 min2 max2 ...)
```

```
Output is also in a set of variables, used by setup writing  procedures.
look into LINE_* and SPEC_* variables.
```

7.4.6 NARROW_INPUT

```
[PDBI\]NARROW_INPUT Q1|Q2|Q3|Q4 Q1|Q2|Q3|Q4

Select  the two entries of the PdBI narrow-band correlator. The PdBI re-
ceivers have 4 GHz bandwidth (for each polarization), from IF=4  GHz  to
IF=8  GHz.  The WIDEX correlator is able to analyse the whole bandwidth,
but the narrow-band correlator can process only two 1 GHz wide bands.

The receiver 4 GHz bandwidth is split into four "quarters":
         Q1 = 4.2-5.2 GHz    Q2 = 5.0-6.0 GHz
         Q3 = 6.0-7.0 GHz    Q4 = 6.8-7.8 GHz
and two of them must be selected as inputs to the  narrow-band  correla-
tor.  Any combination is possible. The polarization that is selected de-
pends on the selected quarter:
  - the correlator input 1 can only be Q1 HOR, Q2 HOR, Q3 VER, Q4 VER
  - the correlator input 2 can only be Q1 VER, Q2 VER, Q3 HOR, Q4 HOR

Example: NARROW_INPUT Q1 Q2 selects Q1 HOR as first input, and Q2 VER as
second input. Simultaneous measurements of the two HOR and VER polariza-
tions is obtained with e.g. NARROW_INPUT Q1 Q1.
```

7.4.7 PLOT

```
    [PDBI\]PLOT [LINE|NARROW|WIDEX]
  or
    [ALMA\]PLOT [FREQUENCY|BASEBAND i]

         [/LIMITS min max]
         [/MOLECULES FileName [Mol1 Mol2 ... Moln]]
         [/WIDTH width]
         [/SPURIOUS [NO]]
         [/ATMOSPHERE [water]]


The PLOT command is used to change the plot options and update the  plot
accordingly.  Except  for  some restrictions on /LIMITS, the options are
valid for all observatories.

Three types of plots can be produced for the Plateau de Bure:
```

```
o LINE mode = plot of the LSB and USB (as produced by the LINE command).
Note that the new generation receivers at PdBI are single-side band: the
image sideband appears in light grey.  Widex and Narrow-band  units  are
indicated.

o  NARROW mode = SSB plot of the two selected entries of the narrow-band
correlator. This plot is aimed at zooming on the two 1 GHz inputs of the
correlator,  as  selected by the NARROW_INPUT command.  The position and
width of the 8 spectral units are drawn.

o WIDEX mode = plot of the WIDEX frequency coverage.

Two types of plots can be produced for ALMA :

o FREQUENCY mode = plot of the LSB and USB ouptut of the  receiver  band
(as produced by the FREQUENCY command).

o BASEBAND mode = plot of the baseband #i. The position and width of the
spectral windows defined with SPWINDOW are also drawn.

After each of the LINE, NARROW_BAND, SPECTRAL  or  WIDEX  commands,  the
plot is updated.
```

PLOT /LIMITS

```
[PDBI\]PLOT LINE       [/LIMITS min max]

[ALMA\]PLOT FREQUENCY  [/LIMITS min max]

Selects  the  IF range (in MHz) to be plotted. This is to zoom on a spe-
cific part of the receiver bandwidth. Only valid in LINE mode (for PDBI)
or FREQUENCY mode (for ALMA).
```

PLOT /MOLECULES

```
[PDBI\ or  ALMA\]PLOT [...] [/MOLECULES [FileName [Mol1 Mol2 ... Moln]]

   Display  the name of molecules and transitions found in the specified
catalog.

   Note: the whole plot is redrawn. Displayed lines are not simply over-
laid on the current existing plot.

Default  is  to  use the GAG_MOLECULE file, distributed with ASTRO but a
```

```
user-defined catalog can also be specified. This file  must  be  a  text
file with entries:
    Freq   'chain'
where  Freq is the rest frequency in GHz and 'chain' the line name to be
plotted by GreG, between single quotes. Example:
    88.632  'HCN'
    89.081  'HCO\u+'
Another supported format is "Comma Separated Value", as produced by many
spreadsheet processors, i.e.
    115.230, HCN J=1-0,
(Depending on the LOCALE, the "comma (,)" may be a "semi comma (;)".)
```

PLOT /WIDTH

```
[PDBI\ or  ALMA\]PLOT [...]   [/WIDTH width]

   PLOT  /WIDTH  width is used to introduce a finite width (in km/s) for
the molecular lines displayed.
```

PLOT /SPURIOUS

```
[PDBI\ ALMA\]PLOT [...]   [/SPURIOUS [NO]]

   Plot or not the position of spurious lines due to interferences.  For
Plateau  de  Bure,  they  are  at IF1=4500 MHZ, 6300 MHz, and at 3 and 4
times the LO1REF frequency; plotting is the default, it can  be  deacti-
vated with PLOT /SPURIOUS NO
```

PLOT /ATMOSPHERE

```
[PDBI\  or ALMA\]PLOT [...]   [/ATMOSPHERE [Water]]

    Display  the  atmospheric transmission (at zenith) and expected Tsys
(at current elevation) according to the specified conditions. Water  can
be specified to overidde the current value.

The  transmission  and Tsys are computed on-the-fly using the ATMOSPHERE
command (see corresponding help). The command ATMOSPHERE /PRINT  can  be
used  to list the input parameters that were used. The ATM model version
can be changed using the SET ATM OLD|NEW command  (the  NEW  version  is
recommended).
```

7.4.8 PRINT

```
[PDBI\]PRINT [filename]

Write  in  an  output  file (default is setup.obs) the OBS command lines
that correspond to the receiver and backend  tuning  selected  with  the
LINE,  NARROW, and SPECTRAL commands. This file can directly be included
in the observing procedure (``setup'' file) to be run at the Plateau  de
Bure.  It can also be executed in ASTRO to (re)produce the the frequency
coverage plot.

Example of output:
  !
  ! Plateau de Bure receiver and backend setup
  ! Written by ASTRO command PRINT on 11-FEB-2008
  !
  ! ----- Receiver -----
  !
  LET RECEIVER 1
  LINE test  100.000000 LSB  LOW  6500.00  57 /RECEIVER 1
  !
  ! ----- IF processor -----
  ! Selected quarters are Q3 VER and Q4 HOR
  !
  NARROW Q3 Q4 /RECEIVER 1
  !
  ! ----- Narrow-band correlator -----
  !
  SPECTRAL 1  80  550.00 /NARROW 1 /BAND LSB /RECEIVER 1
  SPECTRAL 2 320  360.00 /NARROW 1 /BAND DSB /RECEIVER 1
  SPECTRAL 3 320  740.00 /NARROW 1 /BAND DSB /RECEIVER 1
  SPECTRAL 4  80  350.00 /NARROW 2 /BAND LSB /RECEIVER 1
  SPECTRAL 5  20  793.00 /NARROW 2 /BAND LSB /RECEIVER 1
  SPECTRAL 6  20  700.00 /NARROW 2 /BAND LSB /RECEIVER 1
  SPECTRAL 7 320  540.00 /NARROW 2 /BAND DSB /RECEIVER 1
  SPECTRAL 8 320  830.00 /NARROW 2 /BAND DSB /RECEIVER 1
```

7.4.9 SPECTRAL

```
[PDBI\]SPECTRAL   iunit   bandwidth   fcent   /NARROW   1|2   [/BAND
LSB|USB|SSB|DSB]

Select  the  width and position of each spectral unit of the narrow-band
correlator.
  - 'iunit' is the correlator unit number (1 to 8)
  - 'bandwidth' is the bandwidth in MHz (20, 40, 80, 160, or 320)
```

```
  - 'fcent' is the center frequency (in MHz) of the unit in the
     third IF, i.e. the IF at the entry of the narrow-band correlator
     (in the range 100 to 1100 MHz).
The option /NARROW is mandatory, and is used to select  which  entry  of
the  correlator  the  unit is connected to. The SPECTRAL command updates
the current plot by drawing the position and width of the selected  cor-
relator  unit.  The  list of the current correlator setup, including the
number of channels and resolution, is printed out.

Alternatively, the command "SPECTRAL  iunit"  with  no  other  arguments
calls  the  cursor  and  allows one to define interactively the spectral
unit:
  - Left hand click defines the central freuency and the narrow band
    unit
  - +/- increases/decreases the bandwidth
  - < and > shifts the position of the unit by 5 MHz
  - E is used to Exit this mode
The plot is updated after each action.

Option /BAND LSB|USB|SSB|DSB can be used to define the  processing  mode
of  the  selected  correlator unit. There is no practical difference be-
tween LSB and USB tunings. The DSB mode provides twice as many  channels
than  the LSB or USB modes for the same bandwidth, but the central chan-
nels suffer from the Gibbs effect. This mode is therefore not  optimized
for spectroscopic studies. Choosing between an SSB or DSB mode is possi-
ble only if a bandwidth of 160 or 80 MHz has been selected (320  MHz  is
only  available  in  DSB mode; 40 and 20 MHz are only available in SSB).
Default is DSB for 320 MHz wide units, LSB for the other bandwidth.  The
/BAND  option has no consequences on the plot produced by ASTRO, but af-
fects the printout (number of channels and  resolution)  and  the  setup
file produced by the PRINT command.
```

7.4.10 SPWINDOW

```
[ALMA\] SPWINDOW ispw width frequency [/BASEBAND i]
        [/POLAR p] [USE u] [/RESET]

This  command  is used to define a spectral window in the i-th baseband.
The /BASEBAND option is mandatory, unless a a PLOT BASEBAND command  has
been run, in which case the plotted baseband is selected.

The parameters of the spectral window are then defined as follows:
  - 'ispw' is the correlator window number (each baseband has its
    own list) -- Currently, it can only be equal to 1 (one spectral
    window per baseband).
  - 'width' is the bandwidth in MHz: 31.25, 62.5, 125, 250, 500,
```

```
    1000, or 2000. NB: for simplicity, the software accepts and
    corrects 32, 60, 64, 120, 128, 256.
  - 'frequency' is the center frequency (in MHz) of the window in the IF
    domain, as displayed in the plot produced by PLOT BASE.
  - The /POLAR option is used to define how many polarization products
    must be computed (1,2, or 4). Default is 1.
  - The /USE option defines which fraction of the correlator is to
    be used. This modifies the number of output channels, and therefore
    the spectral resolution. Default is 100. Valid values are 3.125%,
    6.25%, 12.5%, 25%, 50%, and 100%. Entries < 1 are accepted (e.g. 0.5
    instead of 50).
Depending on all these input parameters, the software checks whether one
or several correlator modes are available (not all combinations are pos-
sible).  Obvioulsy, defining several windows on one baseband is possible
only if each window uses < 100% of the correlator resources.

The command "SPWINDOW ispw" with no additional parameters calls  an  in-
teractive mode in which the spectral window can be defined with the cur-
sor:
  - Left hand click defines the central frequency.
  - +/- increases/decreases the bandwidth
  - < and > shifts the position of the unit by 5 MHz
  - P changes the number of polarization products (1-2-4)
  - U and I decrease/increase the fraction of the correlator to
    be used for that spectral window.
  - E is used to Exit this mode
The plot is updated after each action.
```

7.4.11 WIDEX

```
[PDBI\]WIDEX

This command is foreseen to provide tuning parameters of the WIDEX  cor-
relator. None of them is currently open to the users, so the command on-
ly plots the frequency coverage of WIDEX.

The WIDEX command is therefore equivalent to PLOT WIDEX.
```