

CLASS

Continuum and Line Analysis Single-dish Software

A GILDAS software

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Version 1.1

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

The GILDAS team welcomes an acknowledgement 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>

Documentation

In charge: P. Hily-Blant¹.

Active developers: J. Pety^{1,3}, S. Guilloteau², B. Delforge³.

Main past contributors: T. Forveille, R. Lucas.

Software

In charge: P. Hily-Blant¹.

Active developers: J. Pety^{1,3}, S. Guilloteau², B. Delforge³.

Main past contributors: T. Forveille, R. Lucas.

1. IRAM
2. Observatoire de Bordeaux
3. Observatoire de Paris

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Chapter 1

Introduction

CLASS is a software package for reducing spectroscopic data obtained on a single-dish telescope. It also has basic functionalities to reduce continuum drifts like pointing or focus.

The originality of CLASS with respect to similar systems already in use is in the way an observation may be identified. In addition to the traditional scan number which can be used to uniquely refer to an observation, the system also enables one to use *Selection Criteria* as in a data base management system. This faculty, added to a powerful command monitor, SIC, allows easy manipulation of large volumes of data; the list of observation numbers to be added to get the mean spectrum at one position need no longer be typed in, but may be found by CLASS itself.

On a standard installation, CLASS is entered by just typing `class`. CLASS is divided in different parts, called “Languages”, which have somewhat independent functions:

- Language LAS contains all the general utility functions to handle the data structure, plot the spectra or drifts and calibrate them.
- Language ANALYSE contains functions to analyse calibrated spectra in more detail.
- Language FIT gathers the spectra fitting functionalities.

Those languages are described in this manual. In addition, CLASS imports many functionalities defined and documented in other GILDAS packages:

- The command line interpreter is imported through the SIC (basic), GUI (for widgets) and VECTOR (miscellaneous) languages.
- The plotting possibilities through the GTVL (basic graphic actions), GREG1 (curve plotting), GREG2 (image plotting) and GREG3 (data cube plotting) languages.
- And the ephemerids and atmospheric contributions through the ASTRO language.

In addition to this manual, the reader should thus consult the SIC manual, and for further processing, the GREG manual.

This version of the CLASS documentation reflects the full rewriting of CLASS in FORTRAN90. In this process, many things have been changed, hopefully improved. If you are an experienced CLASS user, you may first want to consult the IRAM memo which describes only the changes in this version of CLASS.

Chapter 2

Cookbook

This part is a list of recipes enabling the beginner or the occasional user the get on the air very quickly, without losing his time searching the system's on-line HELP facility.

2.1 A CLASSic Session

```
1  device image white
2  set angle seconds
3  set coordinates equatorial
4  file in raw.30m
5  set line 13co(1-0)
6  set source ic348
7  set telescope iram-30m-b30
8  set observed 15-aug-1984
9  find /offset 0 25
10 set weight time
11 average
12 set unit v f
13 set mode x -1 14
14 set mode y -0.5 7.5
15 set plot histogram
16 plot
17 hardcopy /print
18 hardcopy spectrum.ps /dev ps fast
19 hardcopy spectrum.eps /dev eps color
20 set window 3 6 8 10
21 base 4 /plot
22 plot
23 lines 0
24 gauss
25 fit
26 residual
27 plot
28 sic delete reduced.30m
29 file out reduced.30m new
```

```

30  swap
31  write
32  save ic348
33  exit

```

- 1 Define the output device.
- 2-3 Select the coordinate system and angle unit.
- 4 Open the input file.
- 5-9 Build the index according to various criteria.
- 10-11 Averaged all spectra with weights $w_i = \Delta t \Delta \nu / T_{\text{sys}}^2$.
- 12-16 Plot the averaged spectrum in a given velocity interval, with velocity for the lower axis and rest frequency for the upper axis.
- 17-20 Make hardcopies (directly to the printer, in a ps or eps file).
- 21-23 Subtract a polynomial baseline. Plot the fitted baseline. Plot the baseline subtracted spectrum. The baseline does not take into account channels corresponding to x in the two specified windows, in current units (here velocity).
- 24-26 Perform single Gaussian fitting and plot the result.
- 27-28 Compute the residuals and plot them.
- 29-30 Open a new output file.
 - 31 Recover the baseline subtracted spectrum.
 - 32 Write it.
 - 33 Write the input commands in file ic348.class.

2.2 Reading a spectrum from a formatted input file

```

dev xl w
greg1\column x 1 y 2 /file ''filename''
model y x
plot

```

2.3 Exporting a spectrum to a formatted file

```

file in toto
find
get f
sic output toto.dat
for i 1 to channels
  say 'rx[i]' 'ry[i]' /format g12.4 g12.4
next
sic output

```

2.4 Building a Datacube from a CLASS File

The building of a regular grid in CLASS is done in two steps, in a similar fashion as the production of a PdBI regular grid from UV tables. The first step involves the building of a table: the spectra are written as rows in the Gildas internal data format for efficiency (command `table`). When creating the TABLE, the spectra are *not* resampled on a grid. The second step is the resampling of the non-regularly spaced spectra on a regular grid (command `xy_map`).

A simple example is given below where the cube is produced from a single .30m file. Default parameters are used by the `xy_map` command to define both the convolution kernel (1/3 of the *HPBW*) and the output grid (1/2 of the *HPBW*).

```
file in map      ! Open the input file
find            ! Build the index
consistency     ! Check first that the index is consistent
let name thecube ! Use global SIC variables to define output cube name
let type lmv    ! The output cube is named 'thecube.lmv'
table 'name' new ! Build the non-gridded table
xy_map 'name'   ! Grid the data from the table
go view        ! Check the quality of the data reduction with the VIEW tool
```

The following example illustrates the way to build a cube from several .30m files. This is typically the case when the map has been repeated several times and the data have been calibrated and reduced in different files.

```
file in map1    ! Open the input file
find           ! Build the index
consistency     ! Check first that the index is consistent
let name thecube ! Use global SIC variables to define output cube name
let type lmv    !
table 'name' new ! Build the non-gridded table as a new table
file in map2    ! Open the input file
find           ! Build the index
table 'name'    ! Append the index to the current table
file in map3    ! Open the input file
find           ! Build the index
table 'name'    ! Append the index to the current table
...
xy_map 'name'   ! Grid the data from the global table
go view        ! Check the quality of the data reduction with the VIEW tool
```

2.5 Fitting an HyperFine Structure

2.5.1 Assumptions

A1: same excitation temperature for all the components of the multiplet

A2: Gaussian profiles for the opacity as a function of frequency

A3: the lines all have the same width

A4: the multiplet components do not overlap

A5: the main beam temperature is well suited for your source

2.5.2 Parameters of the multiplet

When selecting the HFS method, you must give the name of a file that contains the relative positions and intensities of the components of your multiplet:

```
LAS> method hfs hfs-n2hp.dat
```

Relative intensities may be normalized or not. Here follow two examples, for the N_2H^+ multiplet.

```
7                ! 1st line: Number of components
6.9360  1.       ! 1st column: Velocity shift, for each component,
5.9841  5.       !                (in km/s) with respect to the reference
5.5452  3.       !                component you choose (here the 5th one).
0.9560  5.       ! 2nd column: The relative strength of each component.
0.0000  7.       !                Here, they are not normalized.
-0.6109  3.      !
-8.0064  3.      !
```

```
7                ! As before.
14.9424 1./27.   ! The reference velocity is now that of the last
13.9906 5./27.   ! component.
13.5516 3./27.   ! The intensities are normalized (you could also
8.9624  5./27.   ! put numerical values rather than fractions).
8.0064  7./27.   !
7.3955  3./27.   !
0.       3./27.   !
```

Let us call v_i and r_i the positions and relative intensities of the N components of the multiplet. We define $S = \sum r_i$. In the first case, we thus have $N = 7$ and $S = 27$.

2.5.3 The fitting procedure

According to assumptions A3 and A4, the opacity of the i th component is written:

$$\tau_i(v) = \tau_i \cdot \exp \left[-4 \ln 2 \left(\frac{v - v_{0,i}}{p_3} \right)^2 \right] \quad (2.1)$$

where p_3 is the common FWHM of all components. The central velocity of component i is $v_{0,i} = v_i + p_2$, where p_2 is the velocity of the reference component (*i.e.* the one with $v_i = 0$).

The opacity of the multiplet is the sum of the N opacities:

$$\tau(v) = p_4 \sum_{i=1}^N r_i \cdot \exp \left[-4 \ln 2 \left(\frac{v - v_i - p_2}{p_3} \right)^2 \right] \quad (2.2)$$

Given the opacity $\tau(v)$, the antenna temperature is given by

$$T_{\text{ant}}(v) = \frac{p_1}{p_4} \left(1 - e^{-\tau(v)} \right) \quad (2.3)$$

From these equations, we deduce:

$$\begin{aligned}\tau(v_i + p_2) &= p_4 \cdot r_i && \text{(assumption A4)} \\ \sum_i \tau_i &= p_4 \cdot S \\ T_{\text{ant}}(v_i + p_2) &= \frac{p_1}{p_4} (1 - e^{-p_4 r_i}) \\ T_{\text{ant}}(v_i + p_2) &\approx p_1 \cdot r_i\end{aligned}$$

where the last equality holds in the optically thin regime.

This implies that the physical meaning of p_4 depends on the value of S : If the relative intensities are normalized to unity, then $S = 1$ and p_4 equals the sum of all centerline opacities.

The results of the HFS fitting procedure are:

Line	T ant * Tau	V lsr	Delta V	Tau main
1	1.313 (0.018)	3.783 (0.001)	0.589 (0.003)	0.230 (0.006)

where $T_{\text{ant}} * \text{Tau} = p_1$, $V_{\text{lsr}} = p_2$, $\text{Delta V} = p_3$ and $\text{Tau main} = p_4$.

According to assumptions A1 and A5, the hyperfine structure fitting procedure allows you to deduce the excitation temperature, since (assuming the Rayleigh-Jeans regime is valid, which is not true at $\lambda < 3\text{mm}$...):

$$T_{\text{ant}}(v) = T_A^*(v) = \frac{B_{\text{eff}}}{F_{\text{eff}}} [T_{\text{ex}} - T_{\text{bg}}] (1 - e^{-\tau(v)}) \quad (2.4)$$

Finally, the excitation temperature is given by:

$$T_{\text{ex}} = T_{\text{bg}} + \frac{F_{\text{eff}} p_1}{B_{\text{eff}} p_4} \quad (2.5)$$

Note: the main group opacity is limited to the range 0.1 – 30 since outside these limits, the problem becomes degenerate because the opacity no longer appears in the equations (in the optically thin limit, line ratio no longer depend on the opacity, and in the thick limit, $\exp(-\tau) \ll 1$).

2.5.4 Typical Analysis Sequence

This routine produces the figure 2.1.

```

1 set plot histo
2 set format brief
3 clear
4 clear alpha
5 file in prov.30m
6 find
7 get f
8 modify source TOTO
9 set unit v c
10 method hfs hfs-n2hp.lin
11 minimize
```

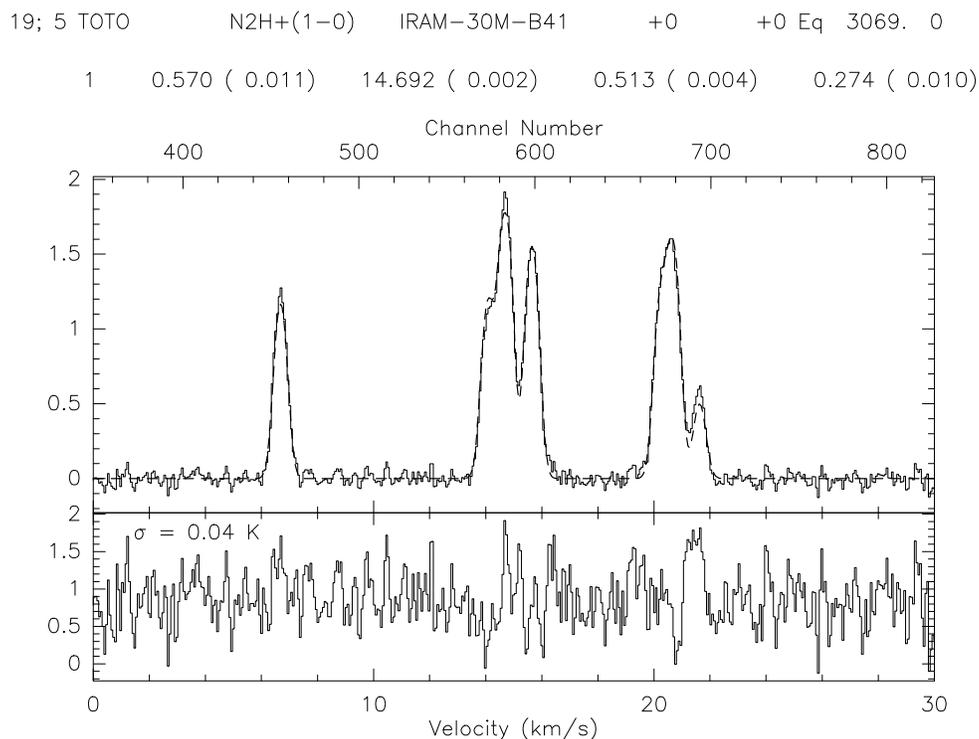


Figure 2.1: Result of the HFS fitting method (see 2.5.4).

```

12 set viewport 0.2 0.9 0.4 0.8
13 set mode x 0 30
14 box n o i p
15 spec
16 title
17 pen /c 0 /w 2 /das 2
18 visualize /pen
19 pen /def
20 display 1.5
21 set viewport 0.2 0.9 0.2 0.4
22 box p o i n /unit v upper
23 residual
24 spectr
25 define real rms
26 compute rms RMS ry
27 gregl\draw test 1 -0.5 "\gs = "'nint(rms*100)/100.'" K" 6 0 /box 7

```

2.6 Subtracting Baseline on Large Datasets

```

1 set verbose off
2 set level 10

```

```
3 dev im w
4 greg1\set plot portrait
5 set format brief
6 set angle sec
7 file in co21.30m
8 find /range -6 6 -6 6
9 load
10 plot /index
11 set window /polygon 1
12 base 1 /index
13 plot /index
14 sic rename window-1.pol my-window-1.pol
15 sic delete co21-base.30m
16 file out co21-base.30m new
17 for i 1 to found
18   get n
19   base 1
20   write
21 next
22 file in co21.bas
23 find
24 load
25 plot /index
```

1. Makes CLASS quiet.
2. Turn off nearly all output messages.
3. Open an image window (necessary to plot 2D images).
4. Change the orientation to portrait.
5. Title in short format.
6. Set arcsecond units.
7. Open the file.
8. Build an index according to offsets.
9. Build a 2D array.
10. Display the whole index.
11. Define a polygon interactively to set spectral windows. By default the polygon is stored in a file window-1.pol.
12. Subtract a 1st order polynom to all records.
13. Display the result.
14. Change the polygon filename (to avoid overwriting it next time).

15. Delete output file if it exists.
16. Open the output file as new.
- 17-21 Make a loop over the index to subtract the baseline and write the result.
- 22-25 Display the result from the output file.

2.7 Reading/Writing FITS file

2.7.1 Exporting CLASS Spectra through FITS

```

1 set angle sec
2 file in co21.30m
3 find /range -2 2 -2 2
4 get f
5 set fits mode spectrum
6 fits write single.fits
7 find /range -2 2 -2 2
8 fits write index.fits /mode index

```

1. Angles are expressed in arcseconds.
2. Open the .30m file.
3. Build the index.
4. Store the first spectrum in R memory.
5. Default mode for writing FITS is set to single spectrum.
6. Write the R memory in FITS format file 'single.fits'.
7. Re-build the index.
8. Write the whole index in FITS format file 'index.fits'.

2.7.2 Importing FITS spectra into CLASS

```

1 set angle sec
2 fits read single
3 sic delete single.30m
4 file out single.30m new
5 write 1
6 file in single.30m
7 find
8 get f
9 plot

```

1. Angles are expressed in arcseconds.
2. Read a single FITS spectrum.

3-4 Open a new .30m file.

3. Write the FITS spectrum in the .30m file with index number 1.

6-9 Check the result by plotting the spectrum from the .30m file.

Chapter 3

User manuel

3.1 Generalities

3.1.1 Data and Log Files

CLASS uses two files of data; one for input and one for output, which may be the same actual file. The input file is only used to read. An observation contains several independent subsections. These file are defined by the command `FILE (IN,OUT,BOTH) Filename`, possibly followed by `NEW` if a new file is to be initialized. The default extension of files is `.30m`. This can be changed with `SET EXTENSION .my_extension`.

CLASS also keeps two log files, named `class.log` and `class.mes`. They are created at CLASS start in the default directory `$HOME/.gag/logs`. This directory is defined in the SIC logical `gag_log`: which can be customized in the user customization file: `$HOME/.gag.dico`. The log files may be used to keep track of a batch or interactive work.

3.1.2 Observation and Version Number

Within CLASS, an *observation* should represent a single observing configuration, *e.g.* a single direction observed at a single central frequency with a single spectral resolution and in one polarization only (*i.e.* a single sky position, front-end and back-end combination). Each observation is given a number, named *observation number* at the time of creation of the CLASS data file. This number is then carried out in further manipulations.

Several version of a given observation may be stored in the same data file. Each version of a given observation thus represent different stages of the data reduction and all the versions of a given observation gives the history of the data processing. Each version of an observation is given a number (starting at 1), named *version number* at the time of creation of the CLASS data file. The version number increases automatically, each time the observation is modified (using `WRITE`). By default, only the last version of a given observation is relevant, *i.e.* `GET` reads the last version of an observation. It is possible (but not recommended) to store an observation without incrementing the version number with the `UPDATE` command so that you can go back to previous stages of reduction in case of big mistakes.

Provided you respect this use of the version number, data reduction can be largely automated. Failing to do this, *i.e.* using the same observation number for very different things at time of creation of the CLASS data file, implies that you have to remember yourself which version corresponds to which configuration.

3.1.3 Scan and Subscan Number

For bookkeeping purpose, CLASS keeps track of a Scan and a Subscan number, which can be used as a selection criterium. The Scan number is attributed at observing time which is carried out in the CLASS data format. Moreover, two different observing mode are nowadays in common use in single-dish telescope:

- The pointed observing mode for which the telescope is pointed toward the source direction during all the integration to obtain only one spectrum. The scan is made of only one spectrum whose intensity is accumulated during the scan duration. Hence the Subscan number is always 1.
- The On–The–Fly (OTF) observing mode for which the telescope drift on source during the integration to make a small map. The scan is here composed of a collection of spectra dumped regularly (typically every 1 second) during a contiguous portion of time. Each dumped spectrum is also tagged by a subscan number whose value is incremented for each new OTF line (both to enable easy selection of a single line inside one OTF scan, and to ensure consistency with the 30m numbering). This subscan number is foreseen to always be greater than 1. There is one exception: when CLASS read data in old format, the subscan number is zero and a warning is issued.

3.1.4 Entry Number and Index

The FIND command offers the possibility to build an index of the observations matching several given selection criteria. The user can then easily process consistently only those observations. Each time a new index is formed using the FIND command, all the selected observations (which will belong to this index) are sequentially attributed a number, named *entry* number. This number goes from 1 to `found`, the number of observations in the current index. The entry number is never saved. It is just used as a number to process the current index in a loop.

Default selection criteria are defined by the SET command. For most selection criteria, an option to the FIND command exists, with the same name, which may be used to impose temporary values to the FIND command; the default values are unchanged by the FIND options.

- SET LINE Name for the line name to be used. A line name of the form ABC* indicates that all lines beginning by ABC are to be selected. The default is *, *i.e.* any line name.
- SET NUMBER n1 n2 for the range of observation numbers. Default is * *, *i.e.* any observation number; * n2 specifies all observation numbers smaller than n2.
- SET OBSERVED d1 d2 for the range of observing dates. A date is specified in the format dd-mmm-yyyy, *e.g.* 19-jan-1985. Default is * *, *i.e.* any date; 19-JAN-1985 * means any date later than January 19th, 1985.
- SET OFFSET o1 o2 for offsets of the position to be used (in the system and units specified by SET COORDINATE and SET ANGLE). Default is * *.
- SET RANGE w e s n is a less restrictive way to specify position offsets. A rectangular area of sky is defined by its west, east, south and north limits (in current angle units).
- SET REDUCED d1 d2 for a range in reduction dates; same specifications and defaults as for SET OBSERVED.

- **SET SOURCE Name** for the source name; same specifications as **SET LINE**.
- **SET SCAN s1 s2** for a range of original scan numbers. Scan numbers should not be confused with Observation numbers (the numbers by which an observation is uniquely identified). They are essentially “history” numbers defined by the acquisition system, but usually with different “observations” (in the CLASS meaning) for a single scan. The scan number is kept only for bookkeeping purpose.
- **SET TELESCOPE Name** for the Telescope name. For the IRAM 30-m telescope, the telescope name contains coded into the last 3 letters the backend used for the observations. Similar conventions are used for spectra coming from Plateau de Bure Interferometer.
- **SET TYPE Name** specifies on which type of observations you deal with: “Continuum”, “Line” or “Skydip”.

The tolerance parameter defined by **SET MATCH** also influences on the position searches, since this parameter (in the current angle unit) is used to check agreement with the specified limits. Another option to the **FIND** command is **/ALL** which enables to find all the versions of all observations satisfying the selection criteria (otherwise only the most recent version is selected). Note that the system is intended to work only with the last version of observations, so that the use of the **/ALL** option should remain exceptional.

Finally, the **SET SORT** force the **FIND** command to sort all the entries of an index in ascending order of a key parameter (*e.g.* lambda or beta offsets). **SET SORT number** implies the default order.

3.1.5 R and T Memories

CLASS keeps 2 observations in memory, in two different buffers, called R and T. The R memory is the only one that may be accessed directly; the T memory is only used for operations on spectra (additions,...). The **GET n** command places the spectrum corresponding to entry number n in the R buffer, while the previous R content is stored in the T buffer. The command **SWAP** exchanges both memories.

3.1.6 Large Set of Spectra

It is today possible with the IRAM–30 m to map a square degree field in CO (2-1). As an order of magnitude, this gives a final spectra cube of about 10^6 spectra with a slightly oversampling of $4''$. An observer who has just spent a few hours observing the same source in OTF mode may want to process all the dumped spectra at once even though they do not belong to the same scan.

The **LOAD** command gathers all the individual spectra currently in the index as a 2D array for future work, in particular visualization. This requires that all the spectra currently in the index are coherent, *i.e.* same source name, same line name and above all exactly the same frequency sampling. The latter can easily be achieved just by resampling. No checking is currently done about this, *i.e.* this is currently the responsibility of the observer to ensure a coherent frequency axis. The **/INDEX** option of commands like **PLOT** or **BASE** modifies there behavior to directly work on the 2D array defined with the **LOAD** command.

Nota Bene: The **STRIP** command which is producing a Velocity-Position plots, is *obsolescent*. Indeed the same functionality can be achieved by the combination **LOAD; PLOT /INDEX** if the index is correctly choosen. And the **LOAD** command is much more powerful.

3.1.7 Variables

The Rope to Hang Yourself

CLASS makes use of SIC variables to allow more flexibility in the processing, in particular in procedures. SIC variables are extremely powerful, with the side effect that if you want, you can corrupt your data by overwriting some information. CLASS attempts to prevent the most disastrous errors by defining some of the most critical variables as `READONLY`. They cannot be overwritten by the user, but their values can be used in expressions, either arithmetic or logical. However, an unprotected mode is available for specific processing using the command `SET VARIABLE`.

Index Variables

The variable `FOUND` refers to the number of observations in the index. It is declared Read-Only of course. Its main use is either to write a SIC loop that goes through the index or to test for actions which should be performed only if something exists in the index. The `FIND` command does not return an error, but set `FOUND = 0`, if it finds nothing. A second variable related to the index is the `INDEX` array, of dimension `FOUND`, which contains the observation numbers of all observations in the index.

Header Variables

The most important header parameters are defined by default as SIC variables in a protected mode. The others, of less frequent use, can be accessed if required by the user (see “Advanced Processing”). The default variables are (RW means Read-Write variable, RO, Read-Only).

<code>TELESCOPE</code>	Character*12,	RW, Telescope name
<code>NUMBER</code>	Integer,	RW, Observation number
<code>VERSION</code>	Integer,	RO, Version number
<code>DATATYPE</code>	Integer,	RO, Type of observation 0 Line, 1 Continuum, 2 Skydip
<code>QUALITY</code>	Integer,	RO, Quality of data
<code>SCAN</code>	Integer,	RO, Original scan number
<code>UTOBS</code>	Double,	RO, UT of observation (Radians)
<code>LSTOBS</code>	Double,	RO, LST of observation (Radians)
<code>AZIMUTH</code>	Real,	RW, Azimuth of observation (Radians)
<code>ELEVATION</code>	Real,	RW, Elevation of observation (Radians)
<code>TSYS</code>	Real,	RW, System temperature
<code>TIME</code>	Real,	RW, Integration time (Seconds)
<code>SOURCE</code>	Character*12,	RW, Source name
<code>LAMBDA</code>	Double,	RW, Longitude of source (Radians)
<code>BETA</code>	Double,	RW, Latitude of source (Radians)
<code>OFF_LAMBDA</code>	Double,	RW, Offset in longitude (Radians)
<code>OFF_BETA</code>	Double,	RW, Offset in latitude (Radians)
<code>EPOCH</code>	Real,	RW, Epoch of coordinates (Years)
<code>LINE</code>	Character*12	RW, Line name
<code>CHANNELS</code>	Integer,	RO, Number of channels
<code>REFERENCE</code>	Real,	RW, Reference channel

FREQ_STEP	Real,	RW, Frequency step by channel (MHz)
VELO_STEP	Real,	RW, Velocity step by channel (km/s)
VELOCITY	Real,	RW, Velocity of reference channel
FREQUENCY	Double,	RW, Rest frequency at reference channel
IMAGE	Double,	RW, Image frequency " " " "
BEAM_EFF	Real,	RW, Telescope beam efficiency
FORWARD_EFF	Real,	RW, Telescope forward efficiency
GAIN_IMAGE	Real,	RW, Image to signal band ratio
WATER	Real,	RO, Water vapor content (mm)
PRESSURE	Real,	RO, External pressure (hPa)
AMBIENT_T	Real,	RO, External temperature (K)
CHOPPER_T	Real,	RO, Chopper temperature (K)
COLD_T	Real,	RO, Cold load temperature (K)
TAU_SIGNAL	Real,	RO, Opacity in signal band
TAU_IMAGE	Real,	RO, Opacity in image band
ATM_SIGNAL	Real,	RO, Atmospheric temperature in signal band
ATM_IMAGE	Real,	RO, Atmospheric temperature in image band
RX	Real[8192]	RO, X values of data points
RY	Real[8192]	RW, Y values of data points

8192 is currently the maximum size of the spectra, but the variables RX and RY are redimensioned to the effective number of channels for each spectrum.

Advanced Processing

All header parameters can be defined as SIC variables for specific processing of the data, either as Read-Only or as Read-Write, using the command `SET VARIABLE`. Read-Write mode is to be used with caution, since even critical variables (*e.g.* the number of channels) can be modified. Refer to command `SET VARIABLE` for more details.

By using the appropriate variables and the SIC mathematical and logical facilities, customized data processing becomes possible, as well as complete data editing.

3.2 Spectra Line Processing

3.2.1 Plotting Spectra

Plotting spectra is controlled by several parameters:

- `SET UNIT` Type defines the unit of the X axis, which may be C (for Channel number), V (for Velocity), F (for Frequency) or I (for Image).
- `SET PLOT` Type defines the plotting type `PLOT` (Normal or Histogram); Normal gives straight lines connecting the data points (this is the default since it is faster). Histogram gives a more realistic representation of spectroscopic data.

- **SET MODE X (or Y) Type** defines the plotting limits in X or Y, where type stands for **TOTAL** (all channels plotted in X, complete scale in Y), **AUTO** (take the plotting limits in use when the spectrum was last written), or two numbers for fixed limits; X or Y specify the axis on which the type is to apply. For X axis, the limits are in the current units (C, V or F). For F, specify the offset from the rest frequency in MHz (note: the caption and the numbers on the axis will refer to absolute rest frequencies).

Single spectrum

Single spectrum are usually plotted using the following commands:

- **BOX**, which plots the frame. The Y axes are labelled in temperature units; the X axes may be in the following units: Velocity, Frequency, Image frequency, or Channel number. The upper X axis may be labelled in a different unit than that of the lower axis. Units for both axes are entered by the command **SET UNIT L U**, where L and U stand for the units of lower and upper axes and may be any of V, F, I, or C. The second parameter U is optional; if not entered, it defaults to L.

BOX accepts the option **/UNIT** which specifies a unit temporarily different from the current one (given by the **SET UNIT** command). The parameter **UPPER** will modify only the unit for the upper axis of the frame. For instance: **BOX /UNIT F UPPER** will give velocities on the lower axis (if this is the current unit specified by **SET UNIT V**) and rest frequencies on the upper axis.

- **SPECTRUM**, which plots the spectrum, in the current mode, clipped into the current box. An offset may be given as argument to plot two spectra above each other for comparison.
- **TITLE**, which writes a header above the frame. The title format is controlled by the **SET FORMAT** command.
- **PLOT**, which performs all of **CLEAR**; **BOX**; **SPECTRUM**; **TITLE** in a single operation.

Spectra map

Using the **MAP** command, it is possible to produce a plot of spectra in the current index, arranged in a map. Use the option **/CELL Size_x Size_y** to specify the size of a spectrum, in current angle units. Without this option a default is taken (the actual separation of the spectra). Option **/GRID** will produce frames around the spectra. The argument **MATCH** can be given to fix the aspect ratio of the boxes to the cell sizes.

The map size can be controlled using commands **SET PAGE** and **SET BOX_LOCATION**. Labels can be suppressed by option **/NOLABEL** (and ticks will not be drawn if of size 0.0). Option **/NUMBER** will add the observation number with each spectrum.

After the **MAP** command has been used, the **POPUP** command may be used to display in another window a spectrum selected either from its observation number or from its offsets. **POPUP** can also be used after the **STAMP** command. The **STAMP** command allows to display many observations at once, without requesting the X and Y axis scales to be fixed.

Large set of spectra

An efficient way to look at a large set of coherent spectra (*e.g.* observed in OTF mode) is to plot them as a 2-D image where the intensity is colour coded. The image is formed by applying the

LOAD on the current index. Then the /INDEX option modify the single spectra plotting commands as follow:

- **BOX /INDEX**, which plots the frame, *i.e.* the entry number (Y axis) as a function of the velocity and/or frequency (X axis). The ranges of X and Y axes are controlled by the SET MODE command. SET MODE Y always control the intensity range.
- **SPECTRUM /INDEX**, which plots the image.
- **TITLE /INDEX**, which writes a header above the frame. Range of parameters (*e.g.* scan number, beta and lambda offsets, ...) are written.
- **PLOT /INDEX**, which performs all of CLEAR; BOX /INDEX; SPECTRUM /INDEX; TITLE /INDEX in a single operation.

3.2.2 Removing Baselines

The BASE command subtracts polynomial baselines of degree < 30 . The fitting algorithm uses Chebyshev polynomials, and does not allow any extrapolation outside the fitting range. It is thus important to fit the baseline out to the maximum extension of the wanted spectrum. If extrapolation is needed, a constant value will be used outside the fitting range, equal to the polynom value at the boundary. The algorithm warns if the polynomial degree is too high. See section 2.6 for a typical baseline fitting session.

The user first defines line windows by the command SET WINDOW with the following syntax:

```
SET WINDOW [w11 wu1 [w12 wu2 [...]]] [/VAR array]
          [/POLYGON [N] [filename1...filenameN]]
          [/NOCURSOR]
```

The POLYGON option enable the definition of 2D polygons on images obtain with LOAD; PLOT /INDEX when working on all the index. Line window values may be entered numerically as arguments, red from variables and line polygons may be red from input files. If available, the cursor may be used to define the windows or polygons. In the window case, enter the values in the same order as above by typing “N” or “ ” (space bar); “C” cancels the last value entered; “H” types a help message and “E” terminates the operation. In the case of polygons, each left clic defines a gon and a right clic terminates the operations. The polygons may leak out of the image. Several polygons may be defined in case the line appear at very different velocities.

Up to 100 windows or 5 polygons may be defined. BASE then fits a polynomial to the part of the spectrum outside the line windows. However, only the “visible” parts of the spectrum are used and bad channels are taken out. The degree of the polynomial is defined by SET BASE n, or temporarily by the BASE command itself with its argument.

Sinusoidal baselines may also be subtracted, using the command BASE SINUS Amplitude Period Phase where Amplitude, Period and Phase are initial guesses for a minimization routine. A linear baseline is added to the sinusoid in any case.

When working on an individual spectrum (not the index), the /PLOT option plots the fitted baseline in the current box. The area in the windows as well as the rms noise, are computed. A baseline can be computed for one spectrum, and then subtracted from a different one using BASE LAST. This may be helpful for example at Pico-Veleta where you may remove from the 100 kHz backend the baseline determined from the 1 MHz one. Be sure that you do not change the X-unit between the time you computed the baseline and the time you remove it...

When working on the whole index, the baseline are fitted spectrum per spectrum and the baseline-corrected spectra are stored in the 2D array ready for plotting with the next `PLOT /INDEX` command. However, baseline fitting results are lost and an explicit loop on the index entry must be use including a new baseline computation) to store the results with the `WRITE` command.

3.2.3 Folding Frequency Switched Spectra

Spectra obtained by Frequency Switching need to be folded to obtain the source spectra. It is usually a good idea to remove a baseline before the spectra are folded in order to use as much baseline as possible. The folding is done by command `FOLD` which reads from the corresponding section all the necessary parameters. `FOLD` only operates on the `R` buffer. The number of channels is decreased to keep only the relevant part of the resulting spectrum.

3.2.4 Adding Spectra

Four parameters define the way spectra are added. These are the align mode, the combination mode, the integration weighting, and the behaviour with respect to bad channels.

Four alignment modes are available, by the means of the command `SET ALIGN Mode`:

- `CHANNEL` in which spectra are added channel by channel. This is only useful when the spectra have been obtained in strictly identic conditions. Warning messages are given when this is not the case.
- `VELOCITY` in which the velocity scale is used to align the spectra. This enables you to add spectra of different origin. An interpolation is performed if needed. If individual spectra have differing spectral resolutions, the lowest spectral resolution is used for the result.
- `FREQUENCY` in which the rest frequency is used to align the spectra.
- `POSITION`, in which continuum drifts are aligned regarding to the position along the drift.

`CHANNEL`, `VELOCITY` and `FREQUENCY` are relevant for Line observations, while `POSITION` is relevant only for Continuum observations. Two combination modes are possible with the command `SET ALIGN MODE Combination`:

- `INTERSECT` where only the intersection of individual spectra is kept.
- `COMPOSITE` where the reunion of the individual spectra is kept (as in a spectral scan for example).

Three weighting types may be used, with the command `SET WEIGHT Type`:

- `TIME` for weights proportional to the observing time, divided by the square of the system noise.
- `SIGMA` for weighting by the inverse square of the rms noise of each individual spectrum.
- `NONE` or `EQUAL` for equal weighting. Caution: equal weighting behaves differently in `AVERAGE` and `ACCUMULATE` commands. `AVERAGE` produces the average of spectra, while `ACCUMULATE` gives the sum of the two spectra. After division by the number of added spectra, `ACCUMULATE` will thus give the same result as `AVERAGE`.

Bad channels are dealt with in two possible ways, defined by the command `SET BAD Mode`:

- `OR` where resulting channels are declared bad if they were declared as such in at least one of the individual spectra.
- `AND` where resulting channels are declared bad if they were bad in all individual spectra.

Default values are `ALIGN CHANNEL INTERSECT`, `WEIGHT TIME`, and `BAD OR`.

Two other parameters control whether summing spectra is allowed or not. Positions are checked according to `SET MATCH Tolerance` or `SET NOMATCH`. If (absolute) positions differ by more than the tolerance parameter, an error message is generated. The tolerance is specified in current angle units. The homogeneity of the calibration is checked according to the `SET CALIBRATION Beam_Tolerance Gain_Tolerance` or `SET CALIBRATION OFF` commands. `Beam_Tolerance` is the maximum difference allowed in the beam efficiencies to add spectra (default 0.02) and `Gain_Tolerance` the maximum difference between the gains in the image band (default 0, which means not checked).

There are two ways of adding spectra: the commands `AVERAGE` and `ACCUMULATE`. `AVERAGE` operates globally on all the spectra in the index, while `ACCUMULATE` adds the R and T buffers into R. `AVERAGE` is generally better for systematic methods, `ACCUMULATE` for special cases. The drawback of `ACCUMULATE` is in the need for initialization; one needs a spectrum in T and a spectrum in R to begin with...

3.2.5 Analyzing profiles

The CLASS user may analyse spectra by fitting profiles. The fitting commands are available from the FIT language. The minimization method is taken from the MINUIT system of CERN, modified and optimized for this purpose. Reliability proved to be good. Five types of profiles are presently available, and can be selected by the `METHOD` command:

- `METHOD GAUSS` This is the default type of profile. One may use up to five Gaussians, which might depend on each other as specified by a system of control codes associated with each variable. For each of these Gaussians, the primary parameters are: 1) Area, 2) Position, and 3) Width (FWHM). The current X unit (for the lower axis) is used. Code 0 means that the parameter is adjustable; 1 that it is fixed; 2 that the parameter (head of group) is adjustable and that another parameter, coded 3, is fixed with respect to it; 4 that the parameter is a fixed head of group.
- `METHOD SHELL` Profiles are like those encountered in envelopes of stars. The primary parameters are Area, Position, Width and Horn to Center ratio. The aspect of the profile varies from parabola (as obtain in optically thick lines) for $\text{Horn/Center} = -1$ to flat-topped lines (unresolved optically thin lines) for $\text{Horn/Center} = 0$ and double peaked profiles (resolved optically thin lines) for $\text{Horn/Center} > 0$. The profile is symmetric. Presently only code 0 and 1 can be used, and up to 5 independent lines can be fitted in a single spectrum. The X unit must be frequency.
- `METHOD NH3(1,1)` or `NH3(2,2)` or `NH3(3,3)`
Profiles taking into account hyperfine structure of ammonia with a Gaussian distribution of velocity are fitted. Primary variables are 1) The product (Main Group Opacity) times (Excitation Temperature minus Background Temperature) 2) Velocity 3) Line Width (FWHM) and 4) Main Group Opacity . Up to 3 independent lines can be fitted, and only codes 0 and 1 are allowed. The X unit must be Velocity.

- **METHOD HFS FileName** This method is similar to the previous one, but the HyperFine Structure parameters are read from a file instead of being known by `CLASS`. The first line of this file must contain the number of hyperfine components (< 40). The other lines must contain, for each component, the velocity offset and the relative intensity. The parameters are the same as for `NH3` method.
- **METHOD CONTINUUM** This method is used for continuum drifts. It fits a Gaussian and a linear baseline in the drift. If beam-switching was used and the reference beam is along the drift direction, two dependent Gaussian are used to optimize signal to noise. The method does not require any user input.

The FIT commands are:

- **LINES N** defines the number of components and prompts for the initial values of the parameters for each component. This command has no effect for method `CONTINUUM`. Parameters are read in list directed format in the following order:

`Code, Intensity, Code, Position, Code, Width, [Code, Parameter 4]`

The code is an integer number between 0 and 4. Note that, though the program works on the area (or other quantities as for `NH3` methods), you have to give the intensity, since this quantity is more intuitive than area. The use of the list directed format makes things easier when only one parameter has to be modified (cf Fortran norms). The number of lines `N` may be zero; in this case the program finds out reasonable starting values by itself.

Values may be also entered graphically if the cursor is available. After entering `LINES N`, first point the cursor to one side of the line, strike one key, point the cursor the other side, strike another key. The program computes the moment of the spectrum between these boundaries and use it to set up starting values. Proceed like this for all components. One drawback of this way of entering values is that you cannot change the control codes. It should be used only for entirely independent and free lines.

- **MINIMIZE** activates minimization, then prints out the results after convergence. A Simplex method is first used to ensure convergence, then a Gradient method to refine the results, and compute the errors.
- **ITERATE** is similar to `MINIMIZE`, but starts from the previous minimization results. Only the Gradient method is used. Consequently, this command is only useful close to the minimum.
- **VISUALIZE [N] [/PEN]** plots the N th component obtained by fitting; if N is not given, the sum of all components is plotted.
- **RESIDUAL N** subtracts the N th component from the current spectrum, or the sum of all components is N is not given). In this process, the `R` spectrum is first copied into `T`, then the difference is done in `R`.
- **DISPLAY** Prints the results of fitting from the current spectrum, without recomputing it ...
- **KEEP** Saves the fit results in the input file, which must be opened also for output. `KEEP` is in fact a reduced version of `UPDATE`, and to be used with the same care as `UPDATE`.
- **SET MASK ...** Defines masks in the spectrum for the fit. This commands has the same syntax and behaviour as `SET WINDOW`. Masked regions will not be used for the fit.

Fit results are always saved by a `WRITE` command and made available through the corresponding variable section (see `SET VARIABLE` help).

3.2.6 Gridding Spectra on a 3-D Data Cube

The command `CUBE` builds a 3-D image from the current index. It is assumed that the current index defines such an image (*i.e.* corresponds to a single line, observed with a single resolution, and towards a single source). The first axis of the cube corresponds to the current X unit, the second to RA (or L) and the third to DEC (or B). Projection information is written so that the coordinate system is automatically recognized when processed by `GILDAS`.

Please refer to the `GILDAS` documentation for later processing. The recommended first steps are i) a transposition (task `TRANSPPOSE` to put the axes in RA,DEC,Velocity ordering and ii) the tasks `FILL_CUBE` (for undersampled data) or `MAKE_CUBE` (for oversampled data) to resample the data cube on a finer grid for nice contouring.

An alternative processing technique is to use command `GRID`, which creates a table suited for map making using the task `GRID_CUBE`. This route is recommended for oversampled data, while the use of `MAP` and `FILL_CUBE` is probably better for undersampled data.

Finally `GRID /IMAGE` will directly produce data cubes from oversampled or undersampled data, using a Gaussian convolution kernel for interpolation, and reasonable defaults for the cube size and pixel size in both axes.

`CUBE` and `GRID` can also produce images or tables of several mathematical functions of the input spectra rather than simple channel maps. Please refer to the internal help for details.

For mapping purpose, `CLASS` is able to produce images at the `GILDAS` format. `GILDAS` (the Grenoble Image and Line Data Analysis System) is an set of routines which is able to process images of up to four dimensions. It contains a variety of routines to transpose, resample, reproject, smooth, add, merge, divide, etc... images, and a superset of `GREG` which allows to produce contour plots from these images. Other programs can also do false color displays of the images on image processors.

3.2.7 Miscellaneous

- `DIVIDE` makes the ratio of the R and T spectra. The two spectra must have the same velocity scale.
- `FFT` plots the power spectrum of the current observation. It might help identify spurious ripples. Editing of the fourier transform is possible, so that these ripples may be suppressed.
- `NOISE` generates a Gaussian noise as intense as in the current spectrum using the rms value determined by the `BASE` command, or using a rms value given as an argument. `NOISE Value NEW` will create a noisy spectrum of given noise level into R, after copying R in T.
- `RESAMPLE` resamples the R spectrum on the specified grid. If the final sampling is coarser than the original one, a smoothing occurs to the final sampling.
- `SMOOTH` operates a Hanning smoothing by default and divide the number of channels by two. Other arguments can be specified to use other methods. `SMOOTH AUTO` uses a sophisticated variable-resolution algorithm, but it requires the channels to be really independent and this is apparently seldom the case in radio astronomy. `SMOOTH GAUSS Width` convolves the spectrum by Gaussian of given Width in current units; it does not take care of bad channels.

`SMOOTH BOX N` make the average of `N` adjacent channels and divides the number of channels by `N`.

3.3 Continuum and Skydip Processing

3.3.1 Continuum

So far, we have handled only Spectroscopic data, but Continuum data can be processed by `CLASS`. Currently, only continuum drifts can be reduced. The basic idea is to treat continuum drifts as spectra would be. Accordingly, very few commands behave differently in Continuum and Spectroscopy modes.

Continuum mode is accessed by typing the `SET TYPE CONTINUUM` command. The prompt then changes to `CAS>` (Continuum Analysis System). You can return to Spectroscopy mode later on typing the `SET TYPE SPECTROSCOPY` or `LINE` command and the prompt changes to `LAS>` (Line Analysis System).

Some commands have slightly different behaviour in Spectroscopy and Continuum modes.

- `SET UNIT` has no effect in Continuum mode.
- `SET ANGLE` also controls the plotting units in Continuum mode.
- `METHOD`: only `GAUSS` and `CONTINUUM` methods are allowed in Continuum mode.
- `LINES` has no effect with `CONTINUUM` method.
- `HEADER` uses a different format for Continuum and Spectroscopy modes.
- `STRIP` produces a map from a set of parallel drifts. The index must define such a set of drifts.
- `FITS` format support is experimental for continuum data.
- With `CONTINUUM` method, `PRINT FIT` command only outputs a single component, and the component number is not written.
- `SET ALIGN CHANNELS` and `SET ALIGN POSITION` are the only available alignment modes in Continuum mode.

Except for these restrictions, the behaviour of other commands is similar. Note that command `FIND` only selects data of the current type.

3.3.2 Skydip Processing

`CLASS` is able to reduce skydip data. Skydip mode must be selected using command `SET MODE SKYDIP` which also changes the prompt to `SAS>` (Skydip Analysis System). Commands `FIND`, `HEADER`, `GET`, `PLOT` and `WRITE` may be used as for Continuum and Line modes, but the only other valid command is `REDUCE` which fits the sky emission using atmospheric information available in the data, and displays the results.

3.4 Communication with the outer world

3.4.1 Listing Scientifically Valuable Results

Command PRINT offers a way to list a number of valuable information on screen or in an ASCII/binary file:

- **PRINT FIT**, which prints the results of profile fits. For each spectrum, N lines are written (N being the number of fitted components), and each line contains in the following order (1) the component number, (2) then observation number, (3,4) the two cartography offsets, (5,6) area of Gaussian and corresponding error, (7,8) same for position, (9,10) same for width, (11) intensity, (12,13) rms on the baseline and on the line. Offset are in the current coordinate system and units. The current method is used.

For Continuum method, only a single Gaussian is written. The written information is oriented towards pointing measurements: (1) the observation number (2,3) Azimuth and elevation (4,5) area of Gaussian and error, (6,7) position, (8,9) width, (10) intensity, (11,12) rms on baseline and signal, (13,14) collimations. All angular values are in the current angle unit. The values are followed by the source name.

- **PRINT AREA**, prints the area of the line computed by the **BASE** command. Each line contains (1,2) offsets, (3) area, (4) rms noise. **PRINT AREA V1 V2 V3 V4 ...**, prints areas within velocity slices (if such is the current X unit, but one could use channels or frequencies). Ranges are V1-V2, V2-V3, V3-V4, ... etc. Each line will contain (1,2) the offsets, followed by the areas in order.
- **PRINT CHANNEL List**, prints values of channels in the list. The list is specified in the **FOR n1 TO n2 BY n3** format. Total number of channels is however limited to 15.
- **PRINT MOMENT V1 V2 V3 V4 ...**, prints moments (area, position, width), of the data within the velocity (or channels or frequencies, depending on the current units) V1-V2, V3-V4, etc... Each line contains (1,2) the offsets, (3,4,5) the moments for V1-V2, (6,7,8) for V3-V4 etc...
- **PRINT POINTING**, prints results of **CONTINUUM** method fits printed in a format adapted to pointing constants measurements. The output is suited for further processing and determination of pointing constants using the **POINT** program.
- **PRINT FLUX**, prints results of **CONTINUUM** method fits printed in a format adapted to flux determination. The output is suited for further processing using the **FLUX** program.

As all commands using a set of spectra, **PRINT** works on the whole current index. Output is by default printed on the screen, but may be directed onto a file by the **/OUTPUT Filename** option.

Alternatively, the same information may be written to a “Table” (a special kind of GILDAS image). The Table format is much faster and suppresses some of the limitations of the formatted output on the number of columns written. Table format is obtained using option **/TABLE Tablename**.

3.4.2 Making Publishable Quality Figures

CLASS has many functionalities to directly produce publishable quality Figures. All the **GREG** commands are imported in **CLASS** to fully annotate plots, superpose spectra with related data,

stack various plots and then make hardcopy (like Post-Scripts files). A few guidelines are given here on essential GREG commands. For more details, users are advised to read the GREG manual.

Moreover, CLASS commands like DRAW and GREG implements fancy functionalities of common use when producing figures around spectra.

GREG functionalities

CLASS is mainly used for interactive look at spectra, hence its default values are all oriented towards fast plotting on screen. These defaults can be changed by command SET. If the value of a parameter is not controlled by CLASS, the command will be passed on to GREG for processing.

The following GREG presentation parameters are useful:

- **SET BOX_LOCATION** It can be set to LANDSCAPE, PORTRAIT, SQUARE or 4 numbers indicating the position of the box in the plot page (in centimeters).
- **SET CHARACTER Size** Control the size of characters in centimeters.
- **SET FONT Quality** Select the character quality to be used, SIMPLEX or DUPLEX. The fonts are identical to the ones used by GREG, and the character handling is the same (in command DRAW TEXT).
- **SET PLOT_PAGE ...** Define the page size. Warning: You will get into trouble if you want to abbreviate this command to SET PLOT as SET PLOT is a valid CLASS command used to indicate whether spectra are broken lines of histograms. A way out of this is to abbreviate the GREG command as G\SET PLOT.
- **SET TICK Size** Define the tick size in centimeters.

Note that you do not need to open a plotting window to produce a hardcopy through the HARDCOPY command. It is only much more convenient, but the plot (*e.g.* sequence of commands) and the way it is displayed (*e.g.* PS format, bitmap on a computer screen) are two completely independent things.

Bridge toward GREG functionalities

The spectra and the results of their analysis (like the fits) are in CLASS internal buffers not always easily accessible for plotting with the GREG commands. CLASS thus implements the GREG command which is intended to produce a direct interface with GREG for plots of spectra. It creates a GILDAS table which can be read using the standard GREG commands for further plotting. The table contains the following columns for Spectra:

1. Intensity
2. Channel number
3. Velocity
4. Offset frequency
5. Rest frequency
6. Image frequency
7. Fitted profiles if any - fit(i),i=0,nline - in column 7+i,
for the current method.

The output table can be put later in a formatted way using GILDAS task LIST if needed. For continuum data, the table contains

1. Intensity
2. Channel number
3. Angular offset (radian)
4. Fitted profile if any.

The table may be used as input to GREG to produce fancy plots, or by the GILDAS software for other applications. In particular, the SIC monitor (command LET) is able to subtract any of the fits from the spectrum to produce residuals if needed. It is possible to merge different tables, add columns to a table, etc... For example, from two spectra at the same velocity resolution it is possible to merge the two tables and compute the ratio of the spectra, as well as the errors on this ratio.

Annotations

CLASS has two DRAW commands to annotate plots: *i*) The standard GREG DRAW command which can be accessed by typing `G\DRAW` (please look at the GREG manual) and *ii*) a special flavor of DRAW customized for annotating spectra. The CLASS flavor is the default one used when typing just DRAW. The basic operations performed by this flavor of the DRAW command are:

- `DRAW TEXT Xpos Ypos "Text" Centering` to draw a text at position (Xpos,Ypos) (in current units) with the specified centering code. This command works more or less like the GREG command of same name. Please refer to the GREG manual for details. In particular, you can include Greek letters and Symbols in the text using the escape character `\`. A strange thing may appear on the screen, but it is O.K. on the plot.
- `DRAW UPPER Xpos "Text"` to draw a vertically oriented text at position Xpos, with a vertical line connecting the beginning of the text to the current spectrum. This text and line are written at position Xpos, in units of the upper axis. Typically, this command is used to mark spectral line identifications.
- `DRAW LOWER Xpos "Text"` same as above, but with Xpos in units of the lower axis.
- `DRAW WINDOW [Level]` shows the current line windows by marks on the graphic plot. Level is an optional arguments indicating at what Y value the marker should be put (Default 0).
- `DRAW MASK [Level]` same as above but for the current masks.
- `DRAW KILL [Channel]` kills the specified channel (current one if using the cursor) by attributing it the “blinking” or “undefined” value.
- `DRAW FILL [Channel]` Fills the specified channel (current one if using the cursor) by interpolation between the nearest non-blanked channels. The channel must have been killed before.

Any other character will not draw anything, but simply returns the cursor position, with corresponding values of the velocity, frequency, image frequency, channel number.

3.4.3 Importing and Exporting Spectra From and To FITS

No data reduction package has all the functionalities any user dream about. But a user may know that the functionality he needs is available in a very specific package. Here comes the need to exchange data between packages. The current standard answer to this problem is FITS. CLASS

to FITS conversion (and vice-versa) is done by command `FITS`. In addition, all functionalities provided by the `SIC` command `DEFINE FITS` are of course available. For a description of the FITS format see the original paper by Wells et al. (Astron. and Astrophys. Suppl.).

The `CLASS FITS` command has the following syntax:

```
FITS READ Filename[.fits]
```

to read a FITS file and create `CLASS` data from it, or

```
FITS WRITE Filename[.fits] [/BITS Nbits] [/MODE SPECTRUM|INDEX]
```

to write a FITS file from `CLASS` data.

In addition, default values can be supplied by the `SET FITS` command.

```
SET FITS BITS Nbits
SET FITS MODE Spectrum|Index|None
```

From FITS to CLASS

```
FITS READ Filename[.fits]
```

will read a FITS file and create `CLASS` data from it. It is expected to work under the following conditions:

1. The `Filename.fits` file contains one spectrum, with (a subset of) the FITS keywords which are described in the previous section. FITS Keyword redefinition is possible.
2. **OR** The `Filename.fits` contains a `BINTABLE`, also with recognized FITS keywords.
3. **No more, no less**

This may look awkwardly restrictive, but is already powerful if you have thought about your data destination when creating the FITS file.

FITS Keyword redefinition

A minimal number of keywords has been defined as part of the FITS standard, but additional ones can be (and have been) added by various groups to support their own needs. Thus, several “flavors” of FITS coexist. A detailed description of the `CLASS FITS` flavors is given in chapter 4. Unknown keywords are normally ignored, but `CLASS` supports FITS keyword redefinition. If you receive a file with scan number coded as `NUMBER` (instead of `SCAN-NUM`), all you need to do is to define a `SIC` symbol named `NUMBER` with translation `SCAN-NUM`. This is done by typing `SIC\SYMBOL NUMBER SCAN-NUM`.

From CLASS to FITS

To write a FITS file from `CLASS` data, use the following command:

```
FITS WRITE Filename[.fits] [/BITS Nbits] [/MODE SPECTRUM|INDEX]
```

The command will create a simple FITS file from the current Spectrum (in `SPECTRUM` mode), or a FITS `BINTABLE` from the current Index (in `INDEX` mode). The number of bits can be controlled. Default values for the mode and the number of bits can be supplied by the `SET FITS` command.

```
SET FITS BITS Nbits
SET FITS MODE Spectrum|Index|None
```

In INDEX mode, it is up to the user to make sure that the index is consistent (same number of channels, etc..., for all spectra in index).

What happened to GFITS?

(gee, you didn't look that old!)

Well, it disappeared. GFITS was mostly intended to work with tapes, which no longer exists nowadays. The new FITS command is simpler to use. The FITS format supported by CLASS has not changed, though.

Chapter 4

Developer Manual (04-dec-2006)

Please check directly the CLASS sources to get the most up-to-date information.

4.1 Internal CLASS Format

4.1.1 Contents of one observation

Data, *i.e.* observational parameters as well as spectra, is organized in the following way:

- One observation is self-contained. All the information needed to reduce it is recorded on the same few disk blocks. It may be one spectrum or one continuum drift.
- Each observation is divided in several sections, containing header parameters or data:
 - General information (date, times, local coordinates, sequence number, ...)
 - Positional information (source, name, astronomical coordinates, epoch, offsets, ...)
 - Spectral information (number of spectra, line names and frequencies, resolutions, number of channels, ...)
 - Data
 - ...

Each type of section is known by the system by means of an integer code. It is not required that all sections be present. Some are written by the observing program at the time of the observations. Some may be dropped during the reduction, being replaced by new ones describing the results of the different stages of the reduction procedure.

- Each observation begins with the following words:

length	content
(bytes)	
4	'2' (identification code)
4	number of logical blocks
4	number of byte describing the observation
4	address of the data section (bytes)
4	length of the data section (bytes)
4	the number of header sections

4 the index entry of the observation
 4*nsec the codes of the sections
 4*nsec the addresses of the sections
 4*nsec the lengths of the sections

Thus the first section will *e.g.* be stored at the address $(28+12*nsec)$, followed by the second section, and so on up to the end of the observation. The length of one particular type of section is not fixed. Adding extra parameters is then possible in each section.

4.1.2 File organization

Data is stored in a direct access file. The record length is 512 bytes. Blocks may contain either observations or indexing information. Each observation begins on a logical block limit. The first block of the file contains a file description in the following format:

length	content
(bytes)	
4	file identification code
4	next block available for writing on the file.
4	number of index entries per index extension.
4	nex: number of index extensions (max. 251)
4*nex	first block number of each index extension

The list of index extension block numbers extends onto the second block of the file.

The file identification code is a 4 character code used to indicate the file type (*single* versus *multiple*) and the internal storage format of the machine which has written the data. Table 4.1 summarizes the possible codes. This enables the reading machine to convert the data to its internal format.

	Vax	IEEE	EEEI
MULTIPLE	'1 '	'1A '	'1B '
SINGLE	'9 '	'9A '	'9B '

Table 4.1: CLASS file identification codes depending on the file type.

Each file contains its own index. Each index entry has a length of 32 words. Thus 4 index entries fill a 512-byte block. Several (by default 64) index entries are grouped in an index extension, of by default 16 consecutive blocks. The addresses of the first block of each extension are stored in the first block. During writing, observations are written at the end of the file, and indexed in the current index extension. When the latter is full, a new index extension is created at the end of the file.

The contents of each index entry may depend on the application. for CLASS spectral line and continuum observations, it contains the following:

name	length	content
	(words)	
XBLOC	1	observation block number
XNUM	1	observation sequence number
XVER	1	observation version number
XSOURC	3	source name (12 char)

XLINE	3	telescope name (12 char)
XDOBS	1	observation date
XDRED	1	reduction date
XOFF1	1	first offset (real, radians)
XOFF2	1	second offset (real, radians)
XTYPE	1	coordinate system ('EQ', 'GA', 'HO')
XKIND	1	Kind of observation (0: spectral, 1: continuum,)
XQUAL	1	Quality (0-9)
XSCAN	1	Scan number
XPOSA	1	Position Angle
XFRONT	2	(8 char) Front-end ID (PROPOSED)
XBACK	2	(8 char) Back-end ID (PROPOSED)
XPROC	2	(8 char) Procedure ID (PROPOSED)
XPROJ	2	(8 char) Project ID (PROPOSED)
(unused)	6	for future extensions

4.2 The Header and Data Sections

Here we describe the contents of the main header sections (excerpts from the storage declarations in the CLASS program itself). Note that, in the data file, the actual length of some of the sections is variable, *e.g.* the length of the switching information section depends on the number of different phases in the switching procedure.

4.2.1 General Parameters

```
! Section -2 /CRPAR/
! GENERAL: General parameters, always present.
integer mgen
integer mgen2
parameter (mgen=9,mgen2=12)
type general
  sequence
  integer(kind=4) :: num      ! [      ] Observation number
  integer(kind=4) :: ver      ! [      ] Version number
  integer(kind=4) :: teles(3)! [      ] Telescope name
  integer(kind=4) :: dobs     ! [MJD-60549] Date of observation
  integer(kind=4) :: dred     ! [MJD-60549] Date of reduction
  integer(kind=4) :: typec    ! [      code] Type of coordinates
  integer(kind=4) :: kind     ! [      code] Type of data
  integer(kind=4) :: qual     ! [      code] Quality of data
  integer(kind=4) :: scan     ! [      ] Scan number
  integer(kind=4) :: subscan  ! [      ] Subscan number
  !
  real(kind=8)    :: ut       ! [ rad] UT of observation
  real(kind=8)    :: st       ! [ rad] LST of observation
  real(kind=4)    :: az       ! [ rad] Azimuth
  real(kind=4)    :: el       ! [ rad] Elevation
  real(kind=4)    :: tau      ! [neper] Opacity
```

```

    real(kind=4)    :: tsys    ! [   K] System temperature
    real(kind=4)    :: time    ! [   s] Integration time
    integer(kind=4) :: xunit   ! [ code] X unit (if xcoord_sec is present)
end type general

```

4.2.2 Position information

```

! Section -3
! POSITION: Position information.
integer mpos
parameter (mpos=18)
type position
  sequence
    integer(kind=4) :: sourc(3) ! [   ] Source name
    real(kind=4)    :: epoch    ! [   ] Epoch of coordinates
    real(kind=8)    :: lam      ! [rad] Lambda
    real(kind=8)    :: bet      ! [rad] Beta
    real(kind=4)    :: lamof    ! [rad] Offset in Lambda
    real(kind=4)    :: betof    ! [rad] Offset in Beta
    integer(kind=4) :: proj     ! [rad] Projection system
    real(kind=8)    :: sl0p     ! [rad] lambda of descriptive system
    real(kind=8)    :: sb0p     ! [rad] beta   of descriptive system
    real(kind=8)    :: sk0p     ! [rad] angle  of descriptive system
  end type position

```

4.2.3 Spectroscopic information (for spectra)

```

! Section -4
! SPECTRO: Spectroscopic information (for spectra).
integer mspec
parameter (mspec=17)
type spectro
  sequence
    integer(kind=4) :: line(3) ! [   ] Line name
    real(kind=8)    :: restf    ! [ MHz] Rest frequency
    integer(kind=4) :: nchan    ! [   ] Number of channels
    real(kind=4)    :: rchan    ! [   ] Reference channels
    real(kind=4)    :: fres     ! [ MHz] Frequency resolution
    real(kind=4)    :: foff     ! [ MHz] Frequency offset
    real(kind=4)    :: vres     ! [km/s] Velocity resolution
    real(kind=4)    :: voff     ! [km/s] Velocity at reference channel
    real(kind=4)    :: bad      ! [   ] Blanking value
    real(kind=8)    :: image    ! [ MHz] Image frequency
    integer(kind=4) :: vtype    ! [code] Type of velocity
    real(kind=8)    :: doppler  ! [km/s] Doppler correction
  end type spectro

```

4.2.4 Baseline information (for spectra or drifts)

```

! Section -5

```

```

! BASE: Baseline information (for spectra of drifts).
integer mwind
integer mbase
parameter (mwind=100,mbase=8+2*mwind)
type base
  sequence
    integer(kind=4) :: deg          ! [          ] Degree of last baseline
    real(kind=4)    :: sigfi       ! [Int. unit] Sigma
    real(kind=4)    :: aire        ! [Int. unit] Area under windows
    integer(kind=4) :: nwind       ! [          ] Number of line windows
    real(kind=4)    :: w1(mwind)   ! [ km/s] Lower limits of windows
    real(kind=4)    :: w2(mwind)   ! [ km/s] Upper limits of windows
  end type base

```

4.2.5 Scan numbers of initial observations

```

! Section -6
! HISTORY: Scan numbers of initial observations.
integer mseq
integer morig
parameter (mseq=100,morig=2*mseq+1)
type history
  sequence
    integer(kind=4) :: nseq        ! Number of sequences
    integer(kind=4) :: start(mseq) ! Start can number of seq.
    integer(kind=4) :: end(mseq)   ! End scan number of seq.
  end type history

```

4.2.6 Default plotting limits

```

! Section -7
! PLOT: Default plotting limits.
integer mplot
parameter (mplot=4)
type plot
  sequence
    real(kind=4)    :: amin       ! [Int. unit] Min Y value plotted
    real(kind=4)    :: amax       ! [Int. unit] Max Y value plotted
    real(kind=4)    :: vmin       ! [ km/s] Min X value plotted
    real(kind=4)    :: vmax       ! [ km/s] Max X value plotted
  end type plot

```

4.2.7 Switching information (for spectra)

```

! Section -8
! SWITCH: Switching information (for spectra).
integer mxphas
integer mfsw
parameter (mxphas=8,mfsw=2+6*mxphas)

```

```

type fswitch
  sequence
  integer(kind=4) :: nphas      ! [   ] Number of phases
  real(kind=8)    :: decal(mxphas) ! [ MHz] Frequency offsets
  real(kind=4)    :: duree(mxphas) ! [  s] Time per phase
  real(kind=4)    :: poids(mxphas) ! [   ] Weight of each phase
  integer(kind=4) :: swmod      ! [code] Switching mode (frequency, position...)
  real(kind=4)    :: ldecal(mxphas) ! [ rad] Lambda offsets
  real(kind=4)    :: bdecal(mxphas) ! [ rad] Beta offsets of each phase
end type fswitch

```

4.2.8 Calibration parameters

```

! Section -14
! CALIBRATION: Calibration parameters.
integer mcalib
parameter (mcalib=25)
type calib
  sequence
  real(kind=4)    :: beeff      ! [   ] Beam efficiency
  real(kind=4)    :: foeff      ! [   ] Forward efficiency
  real(kind=4)    :: gaini      ! [   ] Image/Signal gain ratio
  real(kind=4)    :: h2omm      ! [ mm] Water vapor content
  real(kind=4)    :: pamb       ! [ hPa] Ambient pressure
  real(kind=4)    :: tamb       ! [  K] Ambient temperature
  real(kind=4)    :: tatms      ! [  K] Atmosphere temp. in signal band
  real(kind=4)    :: tchop      ! [  K] Chopper temperature
  real(kind=4)    :: tcold      ! [  K] Cold load temperature
  real(kind=4)    :: taus       ! [neper] Opacity in signal band
  real(kind=4)    :: taui       ! [neper] Opacity in image band
  real(kind=4)    :: tatmi      ! [  K] Atmosphere temp. in image band
  real(kind=4)    :: trec       ! [  K] Receiver temperature
  integer(kind=4) :: cmode      ! [ code] Calibration mode
  real(kind=4)    :: atfac      ! [   ] Applied calibration factor
  real(kind=4)    :: alti       ! [  m] Site elevation
  real(kind=4)    :: count(3) ! [count] Power of Atm., Chopp., Cold
  real(kind=4)    :: lcalof     ! [ rad] Longitude offset for sky measurement
  real(kind=4)    :: bcalof     ! [ rad] Latitude offset for sky measurement
  real(kind=8)    :: geolong    ! [ rad] Geographic longitude of observatory
  real(kind=8)    :: geolat     ! [ rad] Geographic latitude of observatory
end type calib

```

4.2.9 For Skydips observations. No associated data.

```

! Section -16
! SKYDIP: For Skydips observations. No associated data.
integer msky
integer mskydip

```

```

parameter (msky=10,mskydip=10+4*msky)
type skydip
  sequence
    integer(kind=4) :: line(3)      ! [  ] Line name
    real(kind=8)    :: restf       ! [MHz] Rest frequency
    real(kind=8)    :: image       ! [MHz] Image frequency
    integer(kind=4) :: nsky        ! [  ] Number of points on sky
    integer(kind=4) :: nchop       ! [  ] - - - - chopper
    integer(kind=4) :: ncold       ! [  ] - - - - cold load
    real(kind=4)    :: elev(msky)  ! [rad] Elevations
    real(kind=4)    :: emiss(msky) ! [ ?] Power on sky
    real(kind=4)    :: chopp(msky) ! [ ?] Power on chopper
    real(kind=4)    :: cold(msky)  ! [ ?] Power on cold load
  end type skydip

```

4.2.10 Gauss fit results (for spectra or drifts)

```

! Section -9 /CRGAUS/
! GAUSS: Gauss fit results (for spectra or drifts).
integer mxgaus
integer mfit
parameter (mxgaus=5,mfit=3+6*mxgaus)
type gauss
  sequence
    integer(kind=4) :: nline      ! [          ] Number of components
    real(kind=4)    :: sigba     ! [ Int. unit] Sigma on base
    real(kind=4)    :: sigra     ! [ Int. unit] Sigma on line
    real(kind=4)    :: nfit(3*mxgaus) ! [area,v0,fwhm] Fit results
    real(kind=4)    :: nerr(3*mxgaus) ! [area,v0,fwhm] Errors
  end type gauss

```

4.2.11 "Stellar shell" profile fit results (for spectra)

```

! Section -12 /CRSHEL/
! SHELL: "Stellar shell" profile fit results (for spectra).
integer mshell
parameter (mshell=43)
type shell
  sequence
    integer(kind=4) :: nline     ! [] Number of components
    real(kind=4)    :: sigba     ! [] Sigma on base
    real(kind=4)    :: sigra     ! [] Sigma on line
    real(kind=4)    :: nfit(20) ! [] Fit results
    real(kind=4)    :: nerr(20) ! [] Errors
  end type shell

```

4.2.12 Hyperfine structure profile fit results (for spectra)

```

! Section -13 /CRNH3/

```

```

! HFS: "Hyperfine Structure" profile fit results (e.g. NH3, HCN, for spectra).
integer mnh3
parameter (mnh3=27)
type hfs
  sequence
    integer(kind=4) :: nline      ! Number of components
    real(kind=4)    :: sigba     ! Sigma on base
    real(kind=4)    :: sigra     ! Sigma on line
    real(kind=4)    :: nfit(12) ! Fit results
    real(kind=4)    :: nerr(12) ! Errors
end type hfs

```

4.2.13 Hyperfine structure absorption profile fit results (for spectra)

```

! Section -18 /CRABS/
! ABS: "Hyperfine Structure" absorption profile fit results (e.g. NH3, HCN, for spectra).
integer mabs
parameter (mabs=35)
type absorption
  sequence
    integer(kind=4) :: nline      ! Number of components
    real(kind=4)    :: sigba     ! Sigma on base
    real(kind=4)    :: sigra     ! Sigma on line
    real(kind=4)    :: nfit(16) ! Fit results
    real(kind=4)    :: nerr(16) ! Errors
end type absorption

```

4.2.14 Continuum drift description (for drifts)

```

! Section -10 /CRCONT/
! DRIFT: Continuum drift description (for drifts).
integer mcont
parameter (mcont=16)
type drift
  sequence
    real(kind=8)    :: freq      ! [ MHz] Rest frequency
    real(kind=4)    :: width     ! [ MHz] Bandwidth
    integer(kind=4) :: npoin     ! [   ] Number of data points
    real(kind=4)    :: rpoin     ! [   ] Reference point
    real(kind=4)    :: tref      ! [  ?] Time at reference
    real(kind=4)    :: aref      ! [ rad] Angular offset at ref.
    real(kind=4)    :: apos      ! [ rad] Position angle of drift
    real(kind=4)    :: tres      ! [  ?] Time resolution
    real(kind=4)    :: ares      ! [ rad] Angular resolution
    real(kind=4)    :: bad       ! [   ] Blanking value
    integer(kind=4) :: ctype     ! [code] Type of offsets
    real(kind=8)    :: cimag     ! [ MHz] Image frequency
    real(kind=4)    :: colla     ! [  ?] Collimation error Az

```

```

    real(kind=4)    :: colle    ! [ ?] Collimation error El
end type drift

```

4.2.15 Beam-switching parameters (for spectra or drifts)

```

! Section -11
! BEAM: Beam-switching parameters (for spectra or drifts).
integer mbeam
parameter (mbeam=5)
type beam
  sequence
    real(kind=4)    :: cazim    ! [ rad] Azimuth of observation
    real(kind=4)    :: celev    ! [ rad] Elevation of observation
    real(kind=4)    :: space    ! [ rad] Beam spacing
    real(kind=4)    :: bpos     ! [ rad] Position angle of beams
    integer(kind=4) :: btype    ! [code] System for angle
end type beam

```

4.2.16 Double gaussian and baseline fit results (for drifts)

```

! Section -15 /CRPOINT/
! CONTINUUM: Double gaussian and baseline fit results (for drifts).
integer mfcont
parameter (mfcont=19)
type pointing
  sequence
    integer(kind=4) :: nline    ! Number of components
    real(kind=4)    :: sigba    ! Sigma on base
    real(kind=4)    :: sigra    ! Sigma on line
    real(kind=4)    :: nfit(8) ! Fit results
    real(kind=4)    :: nerr(8) ! Errors
end type pointing

```

4.2.17 Comment Section

```

integer, parameter :: mcomm=256
type comment
  sequence
    integer(kind=4) :: ltext    ! Length of comment
    character ctext*1024      ! Comment string
end type comment

```

4.2.18 Data Section

The data section contains the spectrum intensity of each spectral channel. It thus consists of NDATA real values.

4.3 Old OTF data format

This section is kept for backward compatibility. Indeed CLASS is still able to read old OTF data format. Once CLASS, always CLASS...

4.3.1 Data Section Descriptor

```
! Section -30
! Data Section Descriptor.
! (Old OTF data format, kept for backward compatibility).
integer mdescr
parameter (mdescr=4)
type descriptor
  sequence
  integer(kind=4) :: ndump    ! Number of records
  integer(kind=4) :: ldpar    ! Length of data header (longwords)
  integer(kind=4) :: ldatl    ! length of line data      (")
  integer(kind=4) :: ldump    ! length of record          (")
  integer(kind=4) :: rec      ! Current Record Number
end type descriptor
```

4.3.2 Multiple spectra Data Section

A multiple spectra data section contains many spectra, obtained in a single observing scan: typically a drift scan across a source, a on-off scan with a multi-beam receiver, or a drift scan with a multi-beam receiver. The data section is considered as a multiple spectra data section if the special section ‘Data Section Descriptor’ is present. It consists of a R_NDUMP records (individual spectra); each spectrum has R_LDATL line channels, and is followed by a few data associated parameters (R_LDPAR words). The length of each record is thus R_LDUMP=R_LDPAR+R_LDATL; the total length of the data section should be: NDATA=R_NDUMP*R_LDUMP.

The data header presently contains:

offset	type	name	
0	Integer*4		Record number
1	Real*4	AZ	[rad] Telescope Azimuth
2	Real*4	EL	[rad] Telescope Elevation
3	Real*8	ST	[rad] Sideral Time
5	Real*4	LAMOF	[rad] Azimuth offset
6	Real*4	BETOF	[rad] Elevation offset
12	Real*4	UT	[sec] Universal Time in day DOBS

4.4 CLASS FITS format

Starting with dec06 release of GILDAS, the FITS support of CLASS is largely improved. In addition to the old possibility of writing one spectrum per file (see the ‘Simple SPECTRUM Mode’ section), it is now possible to read from the same FITS file, one spectrum in the primary Header/Data Unit and collections of spectra in bintables stored as FITS extensions (see the ‘BINTABLE Mode’). Moreover, it is now possible to store in the same bintable, spectra of different number of

channels. The distinction between the SPECTRUM and BINTABLE mode is mainly historical as the software automatically toggles from one mode to another.

4.4.1 Simple SPECTRUM Mode

FITS headers written by CLASS depend on the informations present in the corresponding CLASS headers. Any missing information will also be omitted in FITS (and vice versa). A typical FITS header written by CLASS looks like this :

```

SIMPLE = T /
BITPIX = 16 /
NAXIS = 4 / (1)
NAXIS1 = 253 / (2)
NAXIS2 = 1 / (3)
NAXIS3 = 1 / (3)
NAXIS4 = 1 / (3)
BSCALE = 0.1038147092913E-03 /
BZERO = -0.2413805246353E+01 /
DATAMIN = -0.5815605640411E+01 /
DATAMAX = 0.9877878427505E+00 /
BUNIT = 'K ' / (4)
CTYPE1 = 'FREQ ' / (5)
CRVAL1 = 0.0000000000000E+00 / Offset frequency
CDELTA1 = 0.1000000014901E+06 / Frequency resolution
CRPIX1 = 0.1345000000000E+03 /
CTYPE2 = 'RA ' / (6)
CRVAL2 = 0.8388750229169E+02 /
CDELTA2 = -0.5555555975722E-02 /
CRPIX2 = 0.0000000000000E+00 /
CTYPE3 = 'DEC ' / (6)
CRVAL3 = -0.1777777752148E+01 /
CDELTA3 = 0.0000000000000E+00 /
CRPIX3 = 0.0000000000000E+00 /
CTYPE4 = 'STOKES ' / (7)
CRVAL4 = 1.0000000000000 /
CDELTA4 = 0.0000000000000 /
CRPIX4 = 0.0000000000000 /
TELESCOP = 'IRAM-30M-B20' /
OBJECT = 'ORI-I-2 ' /
GLAT = 0.0000000000000E+00 / Galactic latitude (8)
GLON = 0.0000000000000E+00 / Galactic longitude (8)
EPOCH = 0.1950000000000E+04 / (9)
BLANK = 0.9878914356232E+00 / Blanking value
LINE = '* ' / Line name (10)
RESTFREQ = 0.1152712040000E+12 / Rest frequency (11)
VLSR = 0.1300000000000E+05 / Velocity of ref. channel (12)
DELTA V = -0.2600757479668E+03 / Velocity resolution (13)
IMAGFREQ = 0.1074062118530E+12 / Image frequency (14)

```

```

TSYS      = 0.4787839660645E+03      / System temperature      (15)
OBSTIME   = 0.7500000000000E+02      / Integration time        (16)
SCAN-NUM= 0.4386000000000E+04      / Scan number            (17)
TAU-ATM   = 0.8740132451057E+00      / Atmospheric opacity    (18)
NPHASE    =                          2      / Number of frequency phases (19)
DELTA F1  = -0.5000000000000E+07      / Frequency offset Phase 1 (20)
PTIME1    = 0.3750000000000E+02      / Duration of Phase 1    (20)
WEIGHT1   = 0.1000000000000E+01      / Weight of Phase 1      (20)
DELTA F2  = 0.5000000000000E+07      / Frequency offset Phase 2 (20)
PTIME2    = 0.3750000000000E+02      / Duration of Phase 2    (20)
WEIGHT2   = -0.1000000000000E+01     / Weight of Phase 2      (20)
BEAMEFF   = 0.56                      / Beam efficiency        (21)
FORWEFF   = 0.88                      / Forward efficiency     (22)
GAINIMAG= 1.0000000000000E+00      / Image sideband gain ratio (23)
ORIGIN    = 'LAS-Grenoble-VAX'      /
DATE      = ' 7/ 9/85'              / Date written           /
DATE-OBS= '29/ 5/85'              / Date observed          /
DATE-RED= ' 7/ 9/85'              / Date reduced           /
ELEVATIO= 0.5064780612975E+02      / Telescope elevation    (24)
AZIMUTH   = 0.1919660046612E+03      / Telescope azimuth      /
UT        = '12:50:47.384'          / Universal time at start /
LST       = '06:09:00.479'          / Sidereal time at start of observation /
HISTORY REL 0.5064780612975E+02      / Telescope elevation    (24)
HISTORY RAZ 0.1919660046612E+03      / Telescope azimuth      /
HISTORY RUT 12:50:47.384      Universal time at start of observation
HISTORY RST 6:09:00.479      Sidereal time at start of observation
HISTORY SCAN LIST 4383-4386          (25)
END

```

1. Although only one axis is really necessary, it is very convenient to define four, use the first one for the channels, and the three last ones to code the positions and stokes parameters.
2. The first axis is used to define effectively the spectrum. Thus NAXIS1 is the number of channels.
3. NAXIS2, NAXIS3, and NAXIS4 are all one for a single spectrum. Note however that it is possible to store a raster map with a similar header as this one.
4. Could be Janskys.
5. First axis defined in terms of frequency (in the signal sideband in case of double sideband operations). The frequency of a specific channel is given by
$$F(i) = \text{RESTFREQ} + \text{CRVAL1} + (i - \text{CRPIX1}) * \text{CDELTA1}$$
in which the Rest frequency RESTFREQ is defined later in the header.
6. Second axis, Right Ascension RA (as in this case) or Galactic Longitude GLON. The information as presented here is slightly incomplete, since it would be in general necessary to have an information about the kind of projection used. On most radio telescopes, it is simply assumed that the angular offset in RA is divided by the cosine of Declination to represent "true" angular offsets (valid only for a small field). Small telescopes may need

more elaborate projection systems. In the current example, the position really observed is

$$\text{Dec} = \text{CRVAL3} + (1 - \text{CRPIX3}) * \text{CDELTA3}$$

$$\text{Ra} = \text{CRVAL2} + (1 - \text{CRPIX2}) * \text{CDELTA2} / \text{COS}(\text{Dec})$$

That is, CDELTA2 and CDELTA3 represents angular offsets from the reference position (CRVAL2,CRVAL3) in a Global Sinusoidal projection (RADIO projection).

7. Stokes parameters as defined in the basic paper of Wells et al.
8. Galactic latitude and longitude of the *reference* position, *i.e.* of the position (CRVAL2,CRVAL3). If one was using galactic coordinates instead of equatorial ones, the RA and DEC would appear here instead.
9. Epoch of these coordinates.
10. Molecular line name, for bookkeeping.
11. Rest frequency.
12. LSR Velocity of the reference channel. Heliocentric velocities can be used also.
13. Velocity spacings of the channels. This information is duplicate with the rest frequency and frequency spacing of channels, but convenient. The velocity of a given channel is thus given by

$$V(i) = \text{VLSR} + (i - \text{CRPIX1}) * \text{DELTA V}$$
14. Image frequency, for double sideband operation.
15. System temperature, necessary for some kind of weighting when adding a number of spectra.
16. Integration time, used for the same reason as above.
17. Scan number, for bookkeeping.
18. Atmospheric opacity in the signal sideband.
19. For multi-phased spectra (*i.e.* frequency switching) number of phases.
20. For each phase, the frequency offset, the phase length and weight.
21. The telescope beam efficiency.
22. The telescope forward efficiency.
23. The ratio of gains in the image and signal sidebands (in case of double sideband operation).
24. Some “History” comments. Whether this information should be given with specific keywords or in an History record is still an open question. This information is not really needed for further data reduction, but it helps bookkeeping.
25. The list of scan numbers of the spectra added to produce this one.

The FITS interface for Continuum data is still experimental. Try it, and send your comments...

4.4.2 BINTABLE Mode

In addition to the simple “one FITS file per Spectrum” mode, CLASS supports the Binary Table extension, in reading and writing. CLASS reads and processes all the Binary Table extension of the FITS file. The FITS keywords for the Binary Table format are similar to those of the simple Spectrum mode, but a complete set of spectra can be handled in a single binary table.

Keywords which would change from one spectrum to the next are handled as Binary columns of the table, with the `TTYPEi` FITS keyword holding the name of the corresponding simple FITS keyword. Reading such FITS files, CLASS will support any value for the `TTYPEi` keywords. If a column and a keyword have the same name, the column prevails. If several columns have the same name (try to avoid this), the last one prevails.

The spectra are handled in a `SPECTRUM` column.

Here is an example with a tiny primary Header Data Unit and a Binary Table extension header.

```

SIMPLE = T
BITPIX = 8
NAXIS = 0
EXTEND = T
BLOCKED = T
ORIGIN = 'My observatory'
CREATOR = 'Me '
END

...

XTENSION= 'BINTABLE'
BITPIX = 8 / Always 8.
NAXIS = 2 / Always 2: tables have 2 dimensions.
NAXIS1 = 7275 / Number of bytes per row.
NAXIS2 = 4 / Number of rows.
PCOUNT = 0 / Usually 0.
GCOUNT = 1 / Always 1.
TFIELDS = 18 / Number of columns.
EXTNAME = 'MATRIX ' / Just a name, not important.
EXTVER = 1 / Always 1.
MAXIS = 4 / Number of dimensions in the data.
MAXIS1 = 1793 / Dummy number of channels (see TTYPE1).
MAXIS2 = 1 /
MAXIS3 = 1 /
MAXIS4 = 1 /
CTYPE1 = 'FREQ ' / Dim1: freq => MAXIS1 = Nb channels.
CRVAL1 = 0.000000000000000E+00 / Frequency offset, always 0.
CDELTA1 = 0.100000000000000E+07 / Frequency resolution [Hz].
CRPIX1 = 0.256500000000000E+03 / Dummy reference channel (see TTYPE18).
CTYPE2 = 'RA '
CRVAL2 = 0.000000000000000E+00
CDELTA2 = 0.000000000000000E+00
CRPIX2 = 0.000000000000000E+00

```

```

CTYPE3 = 'DEC      '
CRVAL3 = 0.00000000000000E+00
CDELTA3 = 0.00000000000000E+00
CRPIX3 = 0.00000000000000E+00
CTYPE4 = 'STOKES  '
CRVAL4 = 0.00000000000000E+00
CDELTA4 = 0.00000000000000E+00
CRPIX4 = 0.00000000000000E+00
SUBSCAN =                1      / Subscan number. Often 1.
LINE = 'CS(5-4)  '      / Name of your line, up to 12 chars.
OBJECT = 'JUPITER  '      / Name of your source, up to 12 chars.
RESTFREQ= 0.2449356430000E+12  / Rest (signal) frequency at ref chan.
VELO-HEL= 0.00000000000000E+00  / Velocity at ref. chan [m.s-1].
VELDEF = 'RADI-HEL'      / Type of velocity.
GAINIMAG= 0.9999999776483E-02  / Ratio Image/Signal.
BEAMEFF = 0.8600000143051E+00  / Beam efficiency.
FORWEFF = 0.8600000143051E+00  / Forward efficiency.
EPOCH = 0.19500000000000E+04   / Epoch of coordinates.
DATE-RED= '15/07/97'      / Date of reduction.
TTYPER1 = 'MAXIS1  '      / Number of channels for this spectrum.
TFORM1 = '1J      '      / [integer]
TTYPER2 = 'SCAN    '      / Scan number.
TFORM2 = '1J      '      / [integer]
TTYPER3 = 'TELESCOP'      / Name of your backend.
TFORM3 = '12A     '      / [Up to 12 characters]
TTYPER4 = 'TSYS    '      / System temperature.
TFORM4 = '1E      '      / [K]
TTYPER5 = 'IMAGFREQ'      / Image freq at ref channel.
TFORM5 = '1E      '      / [Hz]
TTYPER5 = 'DELTA V '      / Velocity resolution.
TFORM6 = '1E      '      / [m.s-1]
TTYPER7 = 'TAU-ATM '      / Atmospheric opacity.
TFORM7 = '1E      '      / [neper]
TTYPER8 = 'MH2O    '      / Water vapor content.
TFORM8 = '1E      '      / [mm]
TTYPER9 = 'TOUTSIDE'      / Atm temperature near the antenna.
TFORM9 = '1E      '      / [K]
TTYPER10 = 'PRESSURE'      / Atm pressure on the antenna.
TFORM10 = '1E     '      / [hPa]
TTYPER11 = 'ELEVATIO'      / Elevation.
TFORM11 = '1E     '      / [deg]
TTYPER12 = 'AZIMUTH '      / Azimuth.
TFORM12 = '1E     '      / [deg]
TTYPER13 = 'DATE-OBS'      / Observing date.
TFORM13 = '23A    '      / 'dd/mm/yy' for ex. See below.
TTYPER14 = 'UT     '      / Universal time at start.
TFORM14 = '1D     '      / [s]

```

```

TTYTYPE15 = 'LST      ' / Sideral time at start.
TFORM15 = '1D      ' / [s]
TTYTYPE16 = 'OBSTIME ' / Integration duration.
TFORM16 = '1E      ' / [s]
TTYTYPE17 = 'SPECTRUM' / Your data.
TFORM17 = '1793E   ' / [K]
TTYTYPE18 = 'CRPIX1  ' / Reference channel for this spectrum.
TFORM18 = '1E      ' / [real]
END

```

Known keywords

HISTORY Some “History” comments. Whether this information should be given with specific keywords or in an History record is still an open question. This information is not really needed for further data reduction, but it helps bookkeeping.

MAXIS Number of axes.

MAXISi Number of elements for axis *i*. *i* goes from 1 to **MAXIS**. The first axis is usually used to define effectively the spectrum. Thus **MAXIS1** corresponds to the number of channels. The second and third one can be used to define the coordinates of the spectra when storing a full spectra cube.

CTYPEi The type of physical coordinate on axis *i*: frequency, velocity, right ascension, time... The unit of the values of **CRVALi** and **CRPIXi** are conventionnally defined by the value of the **CTYPEi** keyword. The authorized values and associated units are

FREQ or **FREQUENCY** Frequency axis. Unit: [Hz]. Frequency for channel number *n* is defined by: $F(n) = \text{RESTFREQ} + \text{CRVALi} + (n - \text{CRPIXi}) * \text{CDELTi}$

LAMBDA or **WAVELENG** wavelength axis. Unit: [m^{-1}].

VELO or **FELO** Velocity axis. Unit: [m.s^{-1}]. **VELO** corresponds to the radio convention while **FELO** implies channels regularly gridded in frequency but expressed as velocity in the optical convention. **CLASS** will process **VELO** and **FELO** in the same way *** JP. The referential is defined by the second part of the keyword:

- **-LSR** or **CITY** or empty second part: Local Standart Rest velocity.
- **-HEL** Heliocentric (barycentric) velocity.
- **-OBS** or **-TOP** The frame of rest of the observer/telescope (topocentric).
- **-EAR** or **-GEO** Geocentric velocity

The full keyword may thus looks like: **FELO**, **VELOCITY**, **VELO-GEO**...

RA- or **RA** Right ascension axis. Unit: [degrees]. Right Ascension **RA** or galactic longitude **GLON**: The information as presented here is slightly incomplete, since it would be in general necessary to have an information about the kind of projection used. On most radio telescopes, it is simply assumed that the angular offset in **RA** is divided by the cosine of Declination to represent “true” angular offsets (valid only for a small field). Small telescopes may need more elaborate projection systems. In the current example, the position really observed is

$$\text{Dec} = \text{CRVAL3} + (1 - \text{CRPIX3}) * \text{CDEL3}$$

$$\text{Ra} = \text{CRVAL2} + (1 - \text{CRPIX2}) * \text{CDEL2} / \text{COS}(\text{Dec})$$

DEC- or DEC Declination axis. Unit: [degrees]. Same caveats as for RA.

GLAT Galactic latitude axis. Unit: [degrees]. Same caveat as for RA.

GLON Galactic longitude axis. Unit: [degrees]. Same caveat as for RA.

TIME or UT or UTC Time axis. Unit: [s]. The time since DATE-OBS.

STOKES Stokes axis. The Stokes parameter of the data as defined in the basic paper of Wells et al.

CRPIXi The array location of the reference pixel along axis i. CRPIXi's value may be a fractional number of pixels and/or outside of the limits of the array. This descriptor is optional for degenerated axes (*i.e.* 0 or 1 element).

CRVALi The value of the physical coordinate on axis i at the reference pixel.

CDELTi The increment in physical coordinates along axis i. This descriptor is optional for degenerated axes. Warning: Although there is a difference between the frequency spacing between channels and the frequency resolution of each channel, CLASS currently handles only one value for both.

BSCALE A value of 1 is assumed when it is undefined. The following formula will be applied to the FITS data: $\text{CLASS_spectrum} = \text{BZERO} + \text{BSCALE} * \text{FITS_spectrum}$

BZERO A value of 0 is assumed when it is undefined. The following formula will be applied to the FITS data: $\text{CLASS_spectrum} = \text{BZERO} + \text{BSCALE} * \text{FITS_spectrum}$

DATAMIN Minimum value of your spectrum. Understood by CLASS but unused.

DATAMAX Maximum value of your spectrum. Understood by CLASS but unused.

BLANK Blanking value. If not specified, -1e38 assumed. BSCALE and BZERO are applied to the blanking value.

PCOUNT Usually 0. But if you provide your data as Variable Length arrays, then you will have to tweak this value which specifies the size of the variable length array heap, plus a gap (if any). See THEAP.

GCOUNT Always 1 in Binary tables.

THEAP Byte offset of heap area. The heap area is where the Variable Length Array data are stored. They are usually stored just after the binary table. The heap does not need to begin at the end of the main table data. The user may choose to provide a gap between the main table and the beginning of the heap. The size of this gap, in bytes, can be found using the value of the THEAP keyword. If there is no gap, the value of THEAP is $\text{NAXIS1} * \text{NAXIS2}$. If there is, the size of the gap is the difference between the value of THEAP and $\text{NAXIS1} * \text{NAXIS2}$. A value of $\text{NAXIS1} * \text{NAXIS2}$ is assumed when this keyword is not defined.

BEAMEFF The main-beam efficiency.

FORWEFF or ETAFSS The forward spillover and scattering efficiency.

GAINIMAG Ratio Image/Signal.

MH2O Water vapor content. Unit: [mm].

PRESSURE The ambient atmospheric pressure. Unit: [hPa].

TOUTSIDE The ambient temperature. Unit [K].

NPHASE Value: from 1 to 8. For multi-phased spectra (i.e. frequency switching) number of phases.

DELTA F_j Frequency offset for phase j . Unit: [Hz].

PTIME j Duration of phase j . Unit: [s].

WEIGHT j Weight of phase j .

TELESCOP A string value giving the telescope name. CLASS truncates this string to the first 12 characters. There is a CLASS convention about TELESCOP, which is not mandatory: TELESCOP contains the name of the instrument, the name of the backend and the name of the subband (if any). For example: “HIFI-HRV-02” for subband 2 of the High Resolution Spectrometer (Vertical polarization) of HIFI (one of the Herschel’s instrument).

AZIMUTH The azimuth at TIME. Unit: [degrees]. If the TIME axis is non-degenerated, then this is the azimuth at the TIME of the first pixel on the TIME axis.

ELEVATIO The elevation at TIME. Unit: [degrees]. Same caveat as for AZIMUTH.

DATE-OBS or DATE_OBS A string giving the observation date and optionally the time at the observation start using the new FITS y2k convention. Since CLASS does not handle the TIMESYS keyword yet to indicate the time system, UTC is assumed. Accepted formats are

- ‘dd/mm/yy’ (1900 is added to yy)
- ‘yyyy/mm/dd’
- ‘yyyy/mm/ddThh:mm:ss.s’, where ‘T’ stands for the letter ‘T’ and has no meaning except as a separator between date and time. The trailing time is ignored, you have to provide it through UT, UTC or LST.

DATE-RED or DATE_RED or DATE Same as DATE-OBS, except it is the date at which the data have been reduced.

SCAN or SCAN-NUM or SCAN_NUM Scan number of the observation, according to the CLASS terminology.

SUBSCAN Subscan number of the observation, according to the CLASS terminology.

UT or UTC Universal time of the start of the observation provided as a string or a number. Then the format is

- ‘hh:mm:ss.s’, when this keyword contains a string.
- The number of seconds after midnight, when this keyword contains a number.

LST Sideral time of the start of the observation. See UT or UTC for information about the format.

OBSTIME or EXPOSURE The effective integration time. Unit: [s]. Necessary for some kind of weighting when adding several spectra.

TSYS The system temperature. Unit: [K]. Necessary for some kind of weighting when adding several spectra.

TAU-ATM or **TAU_ATM** The opacity at **RESTFREQ**. CLASS does not handle the opacity in the image band yet.

EPOCH or **EQUINOX** The epoch of coordinates. Possible values are 1950 or 2000.

OBJECT A string value giving an object name. CLASS truncates this string to the first 12 characters.

LINE Molecular line name, for bookkeeping. CLASS truncates this string to the first 12 characters.

RESTFREQ The observed frequency at the reference pixel of the frequency-like axis. Unit: [Hz].

IMAGFREQ The image sideband frequency corresponding to **RESTFREQ** for double sideband operation. Unit: [Hz].

VELOCITY The velocity at the reference channel. The referential frame must be defined by **VELDEF**.

VELO-LSR or **VLSR** The velocity at the reference channel, understood as a velocity in the Local Standard Rest frame. Thus, you don't need to use **VELDEF** to specify the frame. Unit: [m.s⁻¹].

VELO-OBS or **VELO-TOP** The velocity at the reference channel, understood as a velocity in the frame of rest of the observer/telescope. Thus, you don't need to use **VELDEF** to specify the frame. Unit: [m.s⁻¹].

VELO-HEL The velocity at the reference channel, understood as a velocity in the Heliocentric (barycentric) frame. Thus, you don't need to use **VELDEF** to specify the frame. Unit: [m.s⁻¹].

VELO-EAR or **VELO-GEO** The velocity at the reference channel, understood as a velocity in the Geocentric frame. Thus, you don't need to use **VELDEF** to specify the frame. Unit: [m.s⁻¹].

DELTA V or **DELTA V E L** Velocity spacings of the channels. This information is duplicate with the rest frequency and frequency spacing of channels, but convenient. The velocity of a given channel *n* is thus given by $V(n) = VLSR + (n - CRPIX_i) * DELTAV$. If **DELTA V** is not provided, then the velocity resolution will be calculated by $DELTA V = -c / RESTFREQ * CDELTA 1$, where **CDELTA 1** is the frequency spacing and *c* the celerity of light.

VELDEF The velocity definition and frame (8 characters). The first 4 characters describe the velocity definition. Accepted definitions are

- **RADI** Radio convention.
- **OPTI** Optical convention.
- **RELA** Relativistic convention.

CLASS only handles **RADI** and does not handle **OPTI** or **RELA**. If nothing specified, **RADI** is assumed. This is the list of the values CLASS understands

- **LSR** or **RADI-LSR** Local Standart Rest frame.

- HEL or RADI-HEL Heliocentric (barycentric) frame.
- OBS or RADI-OBS Frame of rest of the observer/telescope. Note that TOP is not handled here.
- EAR or RADI-EAR Geocentric frame.

Known columns and data storage

Most of the keywords described above can be used as column names. The value contained in the column prevails on the value contained in the Keyword. This can be useful if you need to store spectra with different lengths in your table: You can use a column named MAXIS1 containing the number of channels for each spectrum of the table (the trailing bytes required to fill the DATA column will be ignored then).

Here is the list of authorized column names which can also be keywords: DATAMAX, DATAMIN, MAXISi, CRVALi, CRPIXi, CDELTi, BEAMEFF, FORWEFF or ETAFSS, GAINIMAG, MH20, PRESSURE, TOUTSIDE, AZIMUTH, ELEVATIO, DATE-OBS or DATE_OBS, DATE-RED or DATE_RED or DATE, SCAN or SCAN-NUM or SCAN_NUM, SUBSCAN, LST, UT or UTC, TAU-ATM or TAU_ATM, TELESCOP, OBSTIME or EXPOSURE, TSYS, EPOCH or EQUINOX, OBJECT, IMAGFREQ, LINE, RESTFREQ, VELOCITY, VELDEF, VELO-LSR or VLSR, VELO-OBS or VELO-TOP, VELO-HEL, VELO-EAR or VELO-GEO, DELTAV or DELTAVEL.

The following names are exclusively used for columns because their value (your data) can not be factorized

MATRIX or SPECTRUM or SERIES or DATA The spectra intensities. Unit: [K]. This is the only mandatory column. Indeed, why would we make a FITS file without any spectrum? This column must also be unique, *i.e.* only one data column per binary table. The number of elements of this column, specified in TFORM, depends on the way you want to store your data (Fixed or Variable Length Arrays). More explanations are available below

WAVE Frequency of each channel. Unit: [Hz]. This column is optional. If it is present, the spectra is considered as “irregularly sampled”: each channel has its own frequency and the frequency axis description; In other words, the RESTFREQ, CDELTi, CRVALi) keyword are not used at all even when present. MAXISi is still used, since it gives the number of channels. If this column is absent, then the frequency axis will be described in the usual way.

Both the SPECTRUM and WAVE columns must have the same number of elements to obtain a meaningful result. Those columns may either be filled with

Fixed Length Arrays This may be the easiest way to store the data but it may waste a lot of space if you have spectra with different number of channels. The steps are:

1. Description of the data column.
 - (a) First, chose a precision: E for single precision floating point number (4 bytes), D for double precision floating point number (8 bytes).
 - (b) Second, browse your collection of spectra to find the one with the highest number of channels (for example, 1793).
 - (c) Now you can give TFORMi the value 1793E:

```
TTYPE17 = 'SPECTRUM'
TFORM17 = '1793E  '
```

2. Description of the number-of-channel column. If your collection of spectra contains spectra with different sizes, then you must specify the number of channels of each spectrum. To do that, you have to use a column `MAXISi`. `i` corresponds to the number of your frequency/wavelength/velocity axis: usually 1.

```
TTYPE1 = 'MAXIS1  '
TFORM1 = '1J      '
```

The values stored in this column will override the value given to the keyword `MAXIS1` at the beginning of the bintable header. If all your spectra have the same number of channels, then you don't need a `MAXISi` column. But make sure the `MAXISi` keyword at the beginning of the bintable header has the correct value, which is the number of channels of your spectra.

3. Description of the reference channel. You may like to chose the middle of your spectra to be the reference for frequencies. If you have spectra with different sizes, then the reference channels may be different for each spectrum. To override the value of the `CRPIX1` keyword, you must use a `CRPIX1` column.

```
TTYPE18 = 'CRPIX1  '
TFORM18 = '1E      '
```

If your reference channel is always the first one, you can forget about this column and give the value 1 to the `CRPIX1` keyword.

4. Filling the olumns. When it comes to fill the column with the data, make sure you are always storing 1793 (for example) elements. If you are to store a spectrum with only 512 channels, then store those 512 elements and pad with 1281 zeroes (single or double precision zeroes, not bytes). You can see here the waste of space when you have a significant amount of spectra much smaller that the widest one.

Variable Length Arrays To save space and avoid filling half of your data columns with padding zeroes, you can use the Variable Length Array format described in the FITS standard (Definition of the Flexible Image Transport System, version 2.1b, section 8.3.5).

The idea is not to store the data directly in the bintable records, but in the heap area located after the bintable. In the `SPECTRUM` or `WAVE` column, you will find an Array Descriptor which basically consists in a pointer to a location in this heap area (an offset), and a number of elements to read. By doing this, no padding is required any longer. The FITS standart defines two kinds of Array Descriptors: P (two 32bits unsigned integers values) and Q (two 64 bits unsigned integers values). `CLASS` only handles P.

You will not need a `MAXIS1` column in this case, since the number of channels is written in the `SPECTUM` column. You may still need a `CRPIX1` column to define your reference channels.

4.4.3 Once FITS Always FITS

This is the basic principle of FITS, but the IAU FITS committee keeps making revisions of the FITS format. So things are expected to change, with new versions of `CLASS` providing new FITS output, but still reading old FITS.

Chapter 5

Internal Helps

5.1 LAS Language Internal Help

5.1.1 Language

LAS\ Command Language Summary

(+ indicates a NEW command and - an obsolete command)

ACCUMULATE	Add R and T observation.
AVERAGE	Average all the observations of the current index.
BASE [arg]	Subtract a baseline.
BOX	Draw a frame for data.
CALIBRATE	[Re-]Calibrate a spectrum.
CATALOG	Load a line catalog
+CONSISTENCY	Check the consistency of the current index
COPY	Write the current index into output file.
DROP num [ver]	Take a scan out of the current index.
DUMP	List some informations on the R spectrum.
EXTRACT X1 X2 [U]	Extract a subsection of the R spectrum.
FILE type name	Define the input/output files.
FIND	Search the input file for observations.
FITS	Write or read a fits file
FOLD	Fold a Frequency Switched spectrum.
GET [N]	Read a scan in the input file.
HEADER	Display some header information on the R spectrum.
IGNORE List	Ignore scans from the Input file.
LIST [in out]	List header information about an ensemble of scans.
+LOAD	Build a 2D set of spectra from INDEX
MODIFY	Edit and change the scan header.
MULTIPLY fact	Multiply the R spectrum by fact.
NEW_DATA	Wait until new data present in input file.
PLOT	Plot the observation in R, with box and title.
-RECORD	Obsolete
SAVE [name]	Save the current parameters.
SET	Enter a value for a parameter.
SHOW Arg	Display some parameter.

SPECTRUM [Yoff]	Plot the R observation.
SWAP	Exchange the contents of the R and T buffers.
TAG Qual List	Change the quality of scans in the Output file.
TITLE	Write a header above the plotted frame.
UPDATE	Update R in the output file.
WRITE [Obs]	Write R in the output file.

5.1.2 ACCUMULATE

LAS\ACCUMULATE [/NEW]

ACCUMULATE /NEW uses the new averaging engine. See subtopic for details.

ACCUMULATE is used to integrate step by step an ensemble of spectra. The T spectrum is added to the R spectrum with the current weights. R thus contains the current sum, and T the last sum. As command AVERAGE, ACCUMULATE checks for the positional coincidence and calibration homogeneity according to SET MATCH and SET CALIBRATION respectively. Aligment of spectra is checked according to SET ALIGN command. Accumulated spectra may have different spectral resolution. In this latter case, the final spectrum has the coarsest resolution of the two input spectra, and each channel will be the weighted average of the average values of each spectrum in the resulting channel. It is however preferable to accumulate spectra which have the same resolution.

For EQUAL weights, ACCUMULATE computes the sum of the two spectra, allowing addition of an ensemble of spectra after division by the total number of spectra.

For other weightings, ACCUMULATE computes the average of the two spectra.

ACCUMULATE also works on Continuum drift. The aligment may be Channel or Position in this case.

ACCUMULATE /NEW

LAS\ACCUMULATE /NEW [/RESAMPLE [NX Xref Xval Xinc Unit]]

ACCUMULATE is used to add a pair of spectra together. The T spectrum is added to the R spectrum using the current weighting function (see SET WEIGHT). On return R contains the sum spectrum, and T the observation previously in R. To add more than 2 spectra, you should build an index and AVERAGE it in a single step instead (this will prevent cumulative resamplings, respect the respective weights, and preserve at best the noise properties).

The spectra are added channel by channel by default, if possible. Else

the option /RESAMPLE must be invoked (see subtopic for details).

As commands AVERAGE or STITCH, ACCUMULATE checks for the positional coincidence and calibration homogeneity according to SET MATCH and SET CALIBRATION respectively.

For EQUAL weights, ACCUMULATE computes the sum of the two spectra, allowing addition of an ensemble of spectra after division by the total number of spectra. For other weightings, ACCUMULATE computes the average of the two spectra.

ACCUMULATE also works on Continuum drift. The alignment may be Channel or Position in this case.

ACCUMULATE /RESAMPLE

```
LAS\ACCUMULATE /NEW /RESAMPLE [NX Xref Xval Xinc Unit]
```

Without this option, R and T will be added channel by channel. A consistency test will check that they both have the same X axes. SET ALIGN values are ignored in this case. Prefer this solution when possible, since it is faster and safer.

With the /RESAMPLE option, the X axis of the output sum will be automatically computed according to the alignment mode (SET ALIGN). In particular, the output spectrum has the coarsest resolution of the two input spectra. Those are then internally resampled and added on this new axis.

A custom output X axis can be given with the syntax /RESAMPLE NX Xref Xval Xinc Unit. The input spectra are internally resampled and added on this axis. The output resolution can not be better than the coarsest resolution of the input spectra to avoid oversampling.

Remember that if it is enabled, the resampling is time consuming and has non trivial effects on the spectra noise.

5.1.3 AVERAGE

```
LAS\AVERAGE [/NOMATCH] [/NEW]
```

AVERAGE /NEW uses the new averaging engine. See subtopic for details.

Average all the spectra of the current index using the current weighting function (see SET WEIGHT) and alignment mode (see SET ALIGN). The homogeneity of calibration is checked according to SET CALIBRATION. Bad channels are handled according to SET BAD. A sum may be interrupted by <^C>, but the results is then undefined.

The position coincidence of consecutive spectra will not be checked if option `/NOMATCH` is present. Else, this check relies on the current SET `[NO]MATCH` status. See SET `MATCH` to build an index with a given positioning tolerance.

AVERAGE /NEW

```
LAS\AVERAGE /NEW [/NOMATCH] [/RESAMPLE [NX Xref Xval Xinc Unit]]
```

Average all the spectra of the current index using the current weighting function (see SET `WEIGHT`). The spectra are added channel by channel by default, if possible. Else the option `/RESAMPLE` must be invoked (see subtopic for details).

The homogeneity of calibration is checked according to SET `CALIBRATION`. Bad channels are handled according to SET `BAD`. A sum may be interrupted by `<^C>`, but the result is then undefined.

The position coincidence of consecutive spectra will not be checked if option `/NOMATCH` is present. Else, this check relies on the current SET `[NO]MATCH` status. See SET `MATCH` to build an index with a given positioning tolerance.

`AVERAGE` also works on Continuum drift. The alignment may be Channel or Position in this case.

AVERAGE /RESAMPLE

```
LAS\AVERAGE /NEW /RESAMPLE [NX Xref Xval Xinc Unit]
```

Without this option, all the spectra will be added channel by channel. A consistency test will check that they both have the same X axes. SET `ALIGN` values are ignored in this case. Prefer this solution when possible, since it is faster and safer.

With the `/RESAMPLE` option, the X axis of the output sum will be automatically computed according to the alignment mode (SET `ALIGN`). In particular, the output spectrum has the coarsest resolution of the input spectra. Those are then internally resampled and added on this new axis.

A custom output X axis can be given with the syntax `/RESAMPLE NX Xref Xval Xinc Unit`. The input spectra are internally resampled and added on this axis. The output resolution can not be better than the coarsest resolution of the input spectra to avoid oversampling.

Remember that if it is enabled, the resampling is time consuming and has non trivial effects on the spectra noise.

5.1.4 BASE

```
LAS\BASE [Deg] [/PLOT [Ipen]] [/INDEX] [/OBS] [/CONTINUUM [flux]]
LAS\BASE SINUS Amplitude Period Phase [/PLOT [Ipen]]
LAS\BASE LAST [/PLOT [Ipen]]
```

When working on single spectra, BASE copies R into T, then subtracts from R a polynomial baseline of degree Deg, or a sinusoidal baseline if the first argument is SINUS. Zones defined by the SET WINDOW command are not used to fit the baseline. The T content may be recovered with SWAP.

BASE SINUS Amplitude Period Phase

(Phase is in the same unit as the period, usually km/s or MHz) Subtract a sinusoid. Minimization will be done including also a linear baseline in addition to the sinusoid.

BASE LAST

Use the last determined baseline instead of computing a new one. It can be useful to find a baseline from one backend and apply it to another. This also applies for sinusoidal baselines.

BASE /PLOT

Plot this baseline after the minimization, using the Ipen-th pen properties. The pencil 2 (red at startup) is used by default.

BASE /INDEX

Subtracts a baseline to all records that have been loaded. This option is not needed if SET ACTION INDEX. /PLOT and /INDEX options are incompatible.

BASE /OBS

indicate that the baseline is to be fitted to the current R buffer observations. This option is not needed if the action level is OBS (default). /OBS and /INDEX are incompatible.

BASE /CONTINUUM

Divide the spectrum by the baseline rather than subtracting it and multiply by the average flux. This is useful to keep the continuum level, when continuum is present and variations of atmospheric emission are properly subtracted out by fast enough switching. This is of course the case for correlation spectra (e.g. coming from an interferometer). The continuum level will be adjusted to the value of the argument 'flux', if present; e.g. /CONTINUUM 1.0 will produce a spectrum of line-to-continuum ratio. BASE /CONTINUUM does not work with BASE LAST or BASE SINUS.

5.1.5 BOX

```
LAS\BOX [Arg1] [Arg2] [Arg3] [Arg4] [/UNIT Type [UPPER]] [/INDEX]
```

[/OBS]

BOX draws a frame for the spectra. The units and limits are determined according to the options of the SET command (SET MODE ; SET UNIT), and the box size governed by SET BOX.

Arg1(2) modify the labelling of the lower (left) axis
 = P for parallel labels (default for X axis)
 = O for orthogonal labels (default for Y axis)
 = N for no labels
 Arg3 indicates that the ticks are In or Out of the box
 Arg4 controls the labelling of the upper X axis and
 may have the same values as Arg1 or 2 (P, O, N).

The default is BOX P O I

/UNIT

If present, it modifies (with no permanent action) the units of the X axis, or only of the upper X axis if UPPER is specified. Type may be also IMAGE to get image-side-band frequency units. For Continuum data, the /UNIT command has no effect, but the unit is controlled by the SET ANGLE command. /INDEX produces a box suited for 2D color plot with a wedge (the Y-left axis gives the number of spectra).

/OBS

Plot a box for a single spectrum.

/INDEX

Plot a box suited for 2D display: Y axis is the temperature scale, and Z axis is the observation number. All three axis (X, Y and Z) may be defined by using the SET MODE command.

5.1.6 CALIBRATE

LAS\CALIBRATE [KEY val] [KEY val] ...

No arguments: Display the calibration parameters.

Called with a list of arguments in the form "KEY value", where KEY stands for BEAM_EFF, FORWARD_EFF, GAIN_IMAGE, H2O, P_AMB, T_AMB, T_CHOPPER or T_COLD, and value is the corresponding value for, respectively, a (new) Beam efficiency, Forward efficiency, Image/Signal gain ratio, mm of water vapor, ambient temperature, hot load (chopper) temperature, cold load temperature, will recompute the calibration, update the header and rescale the spectrum accordingly.

5.1.7 CATALOG

LAS\CATALOG [Filename]

Read an ASCII file of lines (frequency in GHz and name) into the SIC structure named CLASS%LINE. When the filename is missing, CATALOG uses by default the ASTRO line catalog. Each row of the line file contains the description of a line as follows:

```
115.271204      12CO-1-0
```

Comment lines start with the exclamation mark (!).

The structure has 3 members:

```
CLASS%LINE%N      [      integer] number of lines read
CLASS%LINE%FRES[N] [      double] line frequency in MHz
CLASS%LINE%NAME[N] [character*12] line name
```

5.1.8 CONSISTENCY

```
LAS\CONSISTENCY [/NOCHECK [keyword1] [keyword2] ... ]
```

Check the consistency of the current index according to particular header parameters. By default, check for SOURCE, POSITION, LINE and SPECTROSCOPY consistency. The consistency is automatically tested with some commands (TABLE, LOAD).

/NOCHECK

Without keyword, this option disables all four checks. With a keyword, disable the relevant checks. Current keywords are SOURCE, POSITION, LINE and SPECTROSCOPY.

5.1.9 COPY

```
LAS\COPY [/SORTED]
```

Write all the observations in current index into output file. For efficiency reasons, COPY refuses to copy a sorted index (SET SORT is other than NONE), but user can enforce the copy with the /SORTED option.

5.1.10 DROP

```
LAS\DROP Obs [Ver]
```

Removes an Observation from the current index. The version number must be specified if it is not the last in the input file, even if it is the last version in the current index. This commands has an effect only on the current index, i.e. until a new index is built with a FIND.

5.1.11 DUMP

```
LAS\DUMP [Argument [buffer]] [/SECTION name]
```

With no argument, lists the content of all present header sections of the current R buffer. Arguments are:

A[DDRESSES]	Lists addresses
D[ATA] [buffer]	Lists in addition the data values of buffer (R,T,P)
F[ILE]	Lists information about the input and output files
I[NDEX]	Lists information about the current index
O[TF]	Lists OTF informations
P[LOT]	Lists current plot definition

/SECTION

Lists parameters of a given section. Default is all.

5.1.12 EXTRACT

LAS\EXTRACT [X1 X2 [Unit]]

EXTRACT copies R into T, extracts a subsection of R, and save the result in R.

Without arguments, the cursor is invoked (if available) to define the subsection range. If the arguments X1 and X2 are present, the subsection is defined by this range, in the given Unit (if any) or by default in the current X axis unit (SET UNIT). X2 can be indifferently greater or lower than X1, and Unit is a single character in the four C)hannel, V)elocity, F)requency or I)mage.

If the range overlaps the input spectrum limits, a warning is raised and the missing data is filled with the blanking value. Requesting a range off the input spectrum is an error.

Only spectroscopic data with a regularly sampled X axis is supported.

5.1.13 FILE

LAS\FILE Mode Name [SINGLE|MULTIPLE] [/CONVERT] [/OVERWRITE]

Selects the input and output files.

FILE IN name	open an existing file as input
FILE OUT name	open an existing file as output
FILE BOTH name	select the same file for input and output.
FILE UPDATE name	open a file for Updates only.
FILE OUT name Type	creates a new output file, of the specified type Option /OVERWRITE will force overwriting an existing fil
FILE OUT name Type /CONVERT	converts an existing output file to the specified type

Files have two different Types: SINGLE or MULTIPLE.

File of type MULTIPLE allows to have several version of the same spectrum (same ObservationNumber). This type is the "historical" one for CLASS. It can be opened in all modes.

For file of type SINGLE, the ObservationNumber is a unique identifier of the spectrum: only one version exists. As a consequence a file of this type cannot in general be opened both IN and OUT. Such files can be opened in mode UPDATE, which allows spectra to be modified in place, typically via a TAG or UPDATE command after a MODIFY. Command WRITE is not allowed in this mode.

This new type has been introduced to simplify and speed up On-The-Fly processing.

The default extension is .30m but can be specified using command SET EXTENSION.

5.1.14 FIND

```
LAS\FIND [Append] [New_Data] [/ALL] [/LINE name] [/FREQUENCY f1 f2]
[/NUMBER n1 n2] [/SCAN s1 s2] [/OFFSET o1 o2] [/SOURCE name] [/RANGE w e
s n] [QUALITY q] [/TELESCOPE name] [/SUBSCAN s1 s2] [/ENTRY] [/SECTION
name]
```

FIND performs a search in the input file to build a new index, according to selection criteria defined by the SET command. These criteria may be temporarily modified by the following options:

```
/ALL          all versions of each scan are searched for
              (if not present: only the last version)
/LINE name    search by line name
/FREQUENCY f1 f2 search by signal or image frequency value or range
/NUMBER n1 n2 search for the specified range of observation numbers
/ENTRY n1 n2  search for the specified range of entry numbers
/SCAN s1 s2   search for the specified range of scan numbers
/SUBSCAN s1 s2 search for the specified range of subscan numbers
/OBSERVED d1 d2 search for these dates (JJ-MMM-YYYY)
/OFFSET a1 a2 search for these offsets
/QUALITY q    search for the data of quality better than Q
/RANGE w e s n search for the specified range of offsets
/SOURCE name  search by source name
/TELESCOPE name search for the telescope used
/SECTION name search for observations which have this section defined
```

APPEND

FIND by default overwrites the current index. Found observations may be appended to the current index by specifying the argument APPEND ; an index compression occurs to avoid duplication of scans in the index.

FIND does not return an error if the index is empty, but the variable FOUND is set to 0. FOUND is always set to the number of observations in the index.

Argument NEW_DATA can be used to wait until new data is present in the input file. This possibility is intended for sites where data acquisition is done in CLASS format (Pico Veleta, Plateau de Bure) to use CLASS as an automated quick look facility. The behaviour is similar to that of command NEW_DATA, but all selection criteria are considered and no switching to a new observation type occurs.

5.1.15 FITS

```
LAS\FITS READ file[.fits]
LAS\FITS WRITE file[.fits] /MODE SPECTRUM|INDEX [/BITS nbits]
[/CHECK]
```

Either READ the file.fits FITS file to the CLASS internal data format. Please note that not all FITS files may be read by CLASS, and some header information might be incomplete when doing so.

Or WRITE the file.fits FITS file from the CLASS internal data format. /MODE is a mandatory argument which can take the following values:

```
SPECTRUM  a simple FITS file is written from the current spectrum
           in memory is written.
INDEX      a FITS BINTABLE is written from all the spectra in current
           index. The USER MUST make sure that all index spectra are
           consistent (same source, same line, same frequency setup,
           ...)
```

The number of bits per intensity value used when writing the FITS file may be controlled through the /NBITS optional argument. It can be: 16 or I*2(2 bits integer), 32 or I*4 (4 bits integer) or -32 or R*4 (4 bits real).

The default mode and number of bits can also be specified through the commands

```
SET FITS BITS nbits
SET FITS MODE SPECTRUM|INDEX
```

/CHECK will print the FITS HEADER on the terminal.

5.1.16 FOLD

```
LAS\FOLD
```

Folds a frequency-switched spectrum.

5.1.17 GET

```
LAS\GET [N [version]] [First] [Last] [Next] [Previous]
```

GET copies R into T, and loads the Observation number N in R. The current index initialized by FIND is first explored, then, if needed, the whole input file. If N is absent, the previous (last read) Observation is recovered. If N is FIRST (LAST), the first (last) Observation of the current index is loaded. If N is NEXT (PREVIOUS), the next (previous) Observation in the current index is loaded.

5.1.18 HEADER

```
LAS\HEADER
```

Displays some header information on the R Observation. The FULL format is used, with the informations selected in command SET FORMAT written. The lines written contain (in output order, but not all lines are necessarily present)

- General information line:
 - Scan number and version
 - Source name
 - Line name
 - Telescope name
 - Date of observation
 - Date of last reduction
- Position information line
 - RA or l right ascension or longitude (or azimuth)
 - DEC or b declination or latitude (or elevation)
 - Epoch if equatorial coordinates are used
 - Offsets (in current units)
 - coordinate Eq, Ga, Az
- Quality information line:
 - Quality of calibration (as defined by a SET QUALITY)
 - Tau opacity at zenith
 - Tsys system temperature (outside atmosphere).
 - Time total integration time on source (minutes)
 - El elevation of source
- Spectral information lines (2):
 - N number of channel
 - IO reference channel (real)
 - VO velocity at reference channel
 - Dv velocity resolution (signed)
 - FO rest frequency at reference channel
 - Df frequency resolution (signed)
 - Fi image frequency at reference channel
- Calibration information line:
 - B_ef Beam efficiency of telescope

F_ef Forward efficiency of telescope
 G_im Gain in image band
 - Atmospheric information lines (2):
 H2O millimeter of precipitable water vapor
 Pamb ambient pressure
 Tamb ambient (receiver cabin) temperature
 Tchop Chopper temperature
 Tcold Cold load temperature
 Tatm Atmospheric temperature in the signal band
 Tau Zenith opacity in the signal band
 Tatm_i Atmospheric temperature in the image band
 Tau_i Zenith opacity in the signal band
 - Continuum Drift information lines (2) :
 N Number of points
 IO Reference point
 AO Angle offset at reference point
 Da Angular spacing between points (signed).
 FO Observing frequency
 Df Band pass
 Pos. Ang. : Position angle of the drift.
 followed by the list of Scan numbers added in the observation.

5.1.19 IGNORE

LAS\IGNORE List_of_Observations [/SCAN iscan]

This command can be used to declared the specified list of Observations (from the INPUT file) to be ignored in all FIND operations. They effectively become invisible to CLASS (except in a LIST IN command), until a FILE IN command is typed again. The input file is not physically modified however. The list of observation may have the same format as the index list of a FOR command.

/SCAN iscan

Ignore all observations with scan number 'iscan'.

5.1.20 LIST

LAS\LIST [IN|OUT] [/BRIEF] [/LONG] [/SCAN] [/OUTPUT File] [/TOC]

List header information about an ensemble of Observations. LIST is used for a quick look to Observation headers, in a more or less detailed format. IN or OUT keyword specifies the file to be listed. If absent, the current index is listed. A medium-sized format is used by default.

LIST IN List the whole input file (all versions, see FIND /ALL)

LIST OUT List the whole output file (all versions)

/BRIEF Brief format

/LONG Long format

```

/SCAN          Scan based compact format
/SCAN /BRIEF   Scan numbers followed by the number of spectra in each scan
/TOC          Display the table of contents. See subtopic for details.
/OUTPUT File   Send the list to a file

```

Some options are particularly well suited for large ensemble of spectra: /SCAN displays the index on a scan number basis (defined by a unique SOURCE, LINE, TELESCOPE and SCAN number), /SCAN /BRIEF gives the list of scan numbers with their total number of spectra. /SCAN and /LONG options are incompatible.

LIST /TOC

```
LAS\LIST [IN|OUT] /TOC [Attr1 Attr2 ... AttrN]
```

LIST /TOC displays the Table Of Contents of the current index, or of the input (LIST IN) or output file (LIST OUT). A summary of the different values of each attribute is made, plus a final summary of all the combinations (setups). The attributes can be:

- SOURCE
- LINE
- TELESCOPE
- OFF1
- OFF2
- INDEX
- NUMBER
- BLOCK
- VERSION
- KIND
- QUALITY
- SCAN

By default, SOURCE, LINE and TELESCOPE are used.

The table of contents is also saved in a SIC structure named TOC%, and is updated after each call to the command LIST /TOC. One must take care that subsequent calls to FIND can lead to values in TOC% inconsistent with the current index. In this context advanced users may need to save a copy of TOC%. The standard way to do this in SIC syntax is the following:

```

LAS90> define structure newtoc /like toc
LAS90> let newtoc% toc%

```

5.1.21 LOAD

```
LAS\LOAD [/NOCHECK keyword1 [keyword2 [keyword3] ...]]
```

Pack the whole current index in a 2D array. By default, check the consistency of the index (see CONSISTENCY). The option /NOCHECK allows to

ignore some inconsistency, according to the optional keywords. Current keywords are SOURCE, POSITION, LINE and SPECTROSCOPY.

5.1.22 MODIFY

LAS\MODIFY Item [Values...]

This is a general purpose command to edit and change the current observation header. Some actions are merely presentation "details", others do affect the information in the observation. Among these, RECENTER, WIDTH, IMAGE and SWITCH_MODE are typically used only when the software did not agree with the hardware when the spectra was taken (i.e. when the information in the observation header is wrong). They should be used with caution.

MODIFY actions are limited. You should use the SIC\ command LET to modify header variables which are not available within the MODIFY command (Caution: this is the rope to hang you).

MODIFY BLANKING

LAS\MODIFY BLANKING New0 Change the blanking value in both header and data. This may be required before you can build a consistent strip or cube, specially if the spectra were initially loaded from a FITS tape.

MODIFY BANDS

LAS\MODIFY BANDS

Exchange signal and image bands. This allows line fitting on image band for example. Currently, the spectrum is not rescaled even if the band ratio is not 1.

MODIFY BEAM_EFF

LAS\MODIFY BEAM_EFF Value

Change the beam efficiency. If the beam efficiency previously had a non zero value, the spectrum is rescaled according to the new value. Otherwise, only the beam efficiency is set to the new value.

MODIFY DOPPLER

LAS\MODIFY DOPPLER [SIGN|*|Value]

Change the Doppler factor according to the CLASS convention ($-V/c$). With no argument, checks whether the header value is consistent with the CLASS value computed according to the date and observatory. The checking

precision corresponds to 0.6 m/s in V. A logical SIC variable, DOPPLER_PB, is set to true if the values disagree. If an argument is present:

SIGN change the sign of the Doppler factor but do not recompute it,
 * compute and update the Doppler factor,
 Value set the Doppler factor to <Value>

MODIFY FREQUENCY

LAS\MODIFY FREQUENCY Rfreq

Compute the velocity scale corresponding to a new rest frequency Rfreq. The sky frequency scale is not modified.

MODIFY IMAGE

LAS\MODIFY IMAGE Rimage

Change the image frequency (in MHz).

MODIFY LINENAME

LAS\MODIFY LINENAME "New Name"

Modify the line name (for bookkeeping).

MODIFY OFFSETS

LAS\MODIFY OFFSETS 01 02

Change the offsets. This may be required when you average spectra from different offsets, because the resulting "position" is meaningless (usually the position of the first observation added).

MODIFY POSITION

LAS\MODIFY POSITION Lambda Beta

Change the central position for the source to (lambda_0,beta_0). The offsets are also modified, as to be consistent with the new central position. This command is usefull when different parts of one source are mapped relative to several reference positions. Only RADIO projection is handled.

If the coordinate system is Equatorial:

lambda = lambda_0 x 12 /pi

beta = beta_0 x 180/pi

If the coordinate system is GALactic:

```
lambda = lambda_0 x 180/pi
beta   = beta_0   x 180/pi
```

MODIFY RECENTER

```
LAS\MODIFY RECENTER Rrchan
```

Change the reference channel in order to change the velocity, frequency and image frequency scales. The sky frequency scale is also altered in this command.

MODIFY SOURCE

```
LAS\MODIFY SOURCE source_name
```

Modify the source name.

MODIFY SYSTEM

```
LAS\MODIFY SYSTEM System
```

Change the System in which the center of projection (central position of the source) has been defined. Valid systems are GALACTIC, EQUATORIAL, HORIZONTAL and UNKNOWN. This command is typically used for "foreign" data when the SYSTEM information has not been decoded correctly by the conversion package.

MODIFY TELESCOPE

```
LAS\MODIFY TELESCOPE Name
```

Change the telescope name, for instance from IRAM-30M to 30M-MRT.

MODIFY VELOCITY

```
LAS\MODIFY VELOCITY Rvoff
```

Compute the image and rest frequencies corresponding to a new velocity (in km/s). The sky frequency scale is unchanged by this command.

MODIFY WIDTH

```
LAS\MODIFY WIDTH Rfres
```

Change the frequency resolution (in MHz).

MODIFY SWITCH_MODE

```
LAS\MODIFY SWITCH_MODE Switching_mode Nphase Off_1 Time_1 Weight_1
Off_n Time_n Weight_n
```

Change the description of the switching mode. This command is typically used for "foreign" data when this information has not been decoded correctly by the conversion package.

For each phase, one should specify:

- the offset for the phase (in MHz for frequency switching, in current angular unit otherwise).
- the duration of the phase (in seconds)
- the weight given to phase (arbitrary units)

5.1.23 MULTIPLY

LAS\MULTIPLY Fact

Multiply the R Observation by Fact. MULTIPLY leaves the T Observation unaffected. Note that Tsys is also multiplied by the same (absolute) factor to keep proper weights. If only the data is to be multiplied, use the SIC\LET command on array RY:

SIC\LET RY Fact*RY

5.1.24 NEW_DATA

[LAS\]NEW_DATA

Waits until new data has been written to the input file, then makes a new index from all new data. The type of observation can be changed by this command, but the index will contain only observations of one type. Selection criteria defined by command SET are ignored.

This command can be used to make a quick look or analysis of data produced by a real time acquisition system. Caution: only two programs should access the input file simultaneously, one for writing the other for reading.

5.1.25 PLOT

LAS\PLOT [/INDEX] [/OBS]

PLOT /OBS

Display the Observation in R. It is equivalent to the following sequence of commands:

CLEAR BOX SPECTRUM TITLE

The type of PLOT can be specified by SET PLOT. The limits for the X and Y axes are set by SET MODE X and SET MODE Y.

PLOT /INDEX

Equivalent to the following sequence of commands:

CLEAR BOX /INDEX SPECTRUM /INDEX TITLE /INDEX

Plot a 2-dimensional image (built with the LOAD command) with velocity/frequency for the X axis, index number for the Y-axis, and intensity being rendered as grey/color scale. Use SET MODE Y to choose the color lower and upper limits. Entering command POPUP after PLOT /INDEX enables displaying a single spectrum, selected by clicking with the middle button of the mouse. Use SET MODE Z to control the second dimension of the plot (e.g. number of entries).

Default is /OBS. The default can be modified with SET ACTION.

5.1.26 RECORD

LAS\RECORD k

Obsolete.

5.1.27 SAVE

LAS\SAVE Name

SAVE creates a procedure file of name "Name.CLASS", containing all the current parameters of the program. This file may be executed at any time using the @ command: just type "@ name" after the LAS> prompt, or pass "@ name" as a parameter when invoking CLASS (by typing "CLASS @ name"). This file is composed of standard CLASS commands, and may be edited with any text editor.

5.1.28 SET

LAS\SET something [value1 [value2 [...]]] [/NOCURSOR]

This command is used to set a value for a CLASS parameter. If no argument is given, the default value for the parameter will be restored.

SET ACTION

LAS\SET ACTION I[ndex] O[bservation]

Defines the default action level: current index or current observation (R buffer). Default is OBServation.

SET ALIGN

LAS\SET ALIGN Type Range

Defines the way the spectra to be added are aligned (Type) and combined (Range). Possible combinations are:

Type: C[hannel] for spectra and drift
 V[elocity] for spectra only

F[requency] for spectra only
 P[osition] for drift only
 Range: I[ntersect] or C[omposite]
 Default is SET TYPE C I. Note: This means that continuum drifts in opposite directions are not properly added: ALIGN Position must be specified for that.

SET ANGLE

LAS\SET ANGLE Unit

Specify the angle unit for offsets. Unit is one of: RAD[ian], DEG[ree], MIN[ute of arc], SEC[ond of arc], MAS[milli second of arc]. Default is SECond. The ANGLE unit is also used to display Continuum drifts.

SET BAD

LAS\SET BAD Check

Specify the way ACCUMULATE, AVERAGE and STITCH behave in the case of bad channels. Check may be OR or AND. Default is OR, i.e. the output channel is bad if any of the input channels is bad. AND indicates to use all the non-bad channels (if any) to compute the output channel.

SET BASELINE

LAS\SET BASELINE arg

Specify the degree of polynomial baselines to be subtracted. Default is 1.

SET BOX

LAS\SET BOX L[andscape] P[ortrait] D[efault]

Calls the GREG1\SET PLOT and GREG1\SET VIEWPORT commands with default values suited for CLASS plots. If no keyword, restore the default box: SET VIEW 0.1 0.95 0.15 0.70. The box size can be modified using the GREG1\ command directly as for instance

```
LAS> g\set view 0.2 0.3 0.2 0.3
```

SET CALIBRATION

LAS\SET CALIBRATION [Beam_Tol [Gain_Tol]] or OFF

Specify the tolerance on the Beam efficiency (Beam_Tol) and gain image ratio (Gain_Tol), on turn or calibration checking. A value of 0 means no check. The default values are 0.02 and 0 respectively.

These values are used by commands ACCUMULATE, AVERAGE and STITCH to verify that the calibration is consistent. They are also used by command WRITE which writes the corresponding information in the output file only if Beam_Tol is non zero. Note that because the beam efficiency is less than 1, you could use Beam_Tol=1 to suppress the calibration checking but still write the information.

SET CURSOR

LAS\SET CURSOR Arg

SET CURSOR IS OBSOLETE. Cursor availability is detected automatically, and can be deactivated if needed for some commands by a /NOCURSOR option.

Activates or deactivates the use of cursor for the commands SET WINDOW, SET MASK, SET MODE and LINES, according to the value of Arg: ON or OFF. Default is OFF.

SET DEFAULT

LAS\SET DEFAULT

Restore all parameters to their default value. The default values for individual parameters are documented under the corresponding subtopic.

SET DISPLAY

The following SET Parameter commands affect data display:

LAS\SET ACTION action_level

LAS\SET FORMAT Type

LAS\SET LEVEL interactive_min_value logfile_min_value (obsolete)

LAS\SET MODE A [Type]

LAS\SET PLOT type

LAS\SET SYSTEM Type [Equinox]

LAS\SET UNIT Lower [Upper]

LAS\SET VARIABLE Section_Name [Keyword]

LAS\SET VELOCITY L[sr]H[eliocentric]A[utomatic]

SET EXTENSION

LAS\SET EXTENSION Ext

Defines the default extension for input and output files. Default is '.30m'.

SET FIND

LAS\SET FIND UPDATE|NOUPDATE

FIND will check (or not) for new scans in the input file (see FIND New_Data).

SET FORMAT

LAS\SET FORMAT Type

Set the format of the title of observations plotted. The same format is used by the LIST command. The format may be BRIEF (Observation number and version, Source name, Line name, Telescope name and position offsets), LONG or FULL which is similar to the long format, but also displays the list of original Scans. The default is BRIEF. FULL format is always used for command HEADER.

Other keywords can be specified to indicate which type of information should be written for the LONG and FULL formats. This is done by command

LAS\SET FORMAT Keyword [ON] [OFF] (ON to write the information corresponding to the specified keyword, OFF to ignore it). The keywords are

- POSITION for position of the source, offsets, type of coordinates and Epoch
- QUALITY for the Opacity, System temperature, Elevation, Integration time.
- SPECTRAL for the number of channel, reference channel, velocity and resolution, signal and image frequency and resolution.
- CALIBRATION for the beam and forward efficiencies and the gain image ratio.
- ATMOSPHERE for the water vapor content, pressure, temperatures and opacities in signal and image bands.
- CONTINUUM for continuum drift information
- ORIGIN for the list of added scans.

The default is Position - Quality - Spectral for spectra, Position - Quality - Continuum for drifts. A line of general information is always written in any case.

SET FREQUENCY

LAS\SET FREQUENCY Freq1|* [Freq2|*] [SIGNAL|IMAGE]

Add a selection by frequency for the command FIND. This criterion is suited only for spectroscopic data.

- SET FREQUENCY Freq1
select all observations which frequency range intersects the given frequency,
- SET FREQUENCY Freq1 Freq2
select all observations which frequency range intersects at least partially the given range,
- SET FREQUENCY * Freq2

```

    select all observations which frequency range is at least partial-
    ly under Freq2,
- SET FREQUENCY Freq1 *
    select all observations which frequency range is at least partial-
    ly above Freq1,
- SET FREQUENCY *
    select all observations i.e. disable the selection by frequency.
    This is the default.

```

An optional keyword can be added after the values to indicate whether the selection should be performed by SIGNAL or IMAGE frequencies. Default is SIGNAL.

Users should be aware that this selection criterion requires to read more informations in the observation header, and thus has a computation cost which can become important for large datasets.

SET LEVEL

```
LAS\SET LEVEL interactive_min_value logfile_min_value
```

SET LEVEL IS OBSOLETE AND HAS NO EFFECT ANYMORE.

It can be mimicked with the SIC MESSAGE command (see HELP for details). To alter the verbosity of CLASS commands to terminal and to message file, one should modify the message filters of the CLASS package.

For example:

```

LAS90> SIC MESSAGE CLASS S=FEW ! Change the on-screen CLASS filter
LAS90> SIC MESSAGE CLASS      ! Print the two CLASS filters
class  on-screen  active  filter: FEW-----
class  to-mesfile active  filter: FEWRI--CU

```

This keeps only the most important messages (Fatal, Errors, and Warnings) to the terminal, whereas Results, Informations and Commands are also printed in the message file by default.

SET LINE

```
LAS\SET LINE Name
```

FIND will select all observations according to the specified line name. Default is *. Wildcards are accepted at any position in the line name (e.g. NAM*, N*ME or N*M*): they match 0 or more characters.

SET MASK

```
LAS\SET MASK [m11 m12 [...]] [/VAR array]
```

Defines a mask for the Gaussian fits by its boundaries. If available, the cursor will be used to specify missing arguments, unless option

/NOCURSOR is present. When using the cursor, enter: N (or Left mouse button) to enter a value, C (or Middle button) to cancel the last entry, H for help, E (or Right button) for exit. The boundaries are in current unit. Default is no mask. The boundaries are in current unit. See DRAW MASK to display the mask(s).

SET MASK /VAR mask_array

Define the masks from rank 1 array mask_array[1+2*NMASK]. The array must be of the following form:

```
mask_array[1]=NMASK      number of masks
mask_array[2*i:2*i+1]   boundaries of mask num. 'i'
```

SET MAP

LAS\SET MAP [Clear|Normal]

Will Clear (or Not) the screen before processing a MAP command. However, a "MAP Where" command does not clear the screen even in a "LAS\SET MAP Clear" mode.

SET MATCH

LAS\SET MATCH Tol

Turn on the checking of position-matching in ACCUMULATE, AVERAGE and STITCH. Tol is the position tolerance in current units. The default is SET MATCH 2 (arcsec). The tolerance is also used in FIND, MAP and a few other commands such as CUBE.

SET MODE

LAS\SET MODE X | Y | Z | ALL [mode]

Select the scale mode for axis X, Y or Z, or all. The mode can be:

AUTO : limits as found in the observation header (DEFAULT)

TOTAL : all data plotted

[void]: i) limits are entered explicitly by the user

LAS\set mode x x1 x2

ii) limits are entered interactively when no mode is given (if the cursor is available)

For 2D data (built with the LOAD command), SET MODE Y defines the color range. The second dimension range (e.g. observation number) is defined with SET MODE Z.

SET NOMATCH

LAS\SET NOMATCH

Turn off checking of position-matching in ACCUMULATE, AVERAGE and STITCH. This does not change the tolerance for the other functions like FIND and MAP.

SET NUMBER

```
LAS\SET NUMBER n1 n2
```

FIND will select all Observations with numbers between n1 and n2. Default is * *.

SET OBSERVED

```
LAS\SET OBSERVED d1 d2
```

FIND will select all Observations with observing dates between d1 and d2. Dates are specified as DD-*MMM*-*YYYY* (i.e. 14-JUL-1789). Default is * *.

SET OFFSETS

```
LAS\SET OFFSETS o1 o2
```

FIND will select all observations with offsets within the specified tolerance (SET MATCH) of o1 and o2. See also SET RANGE. Default is * * (select all offsets).

SET PLOT

```
LAS\SET PLOT type level
```

Set the plotting type and level. Level is I[ndex] or S[can]. If level is S, then type is N[ormal] or H[istogram]. Default is normal (50% faster plot).

SET POSANGLE

```
LAS\SET POSANGLE amin amax
```

Specify the position angle range (continuum drifts only) for subsequent searches.

SET PROCESSING

The following SET Parameter commands control data processing options:

```
LAS\SET ALIGN Type Range
```

```
LAS\SET BAD Check
```

```
LAS\SET BASE arg
```

```
LAS\SET CALIBRATION [Beam_Tol [Gain_Tol]] or OFF
```

```

LAS\SET MASK [m11 m12 [...]] [/VAR array]
LAS\SET MATCH Tol
LAS\SET NOMATCH
LAS\SET TYPE CONTINUUM or LINE or SKYDIP
LAS\SET VARIABLE Section_Name [Keyword]
LAS\SET VELOCITY L[sr]H[eliocentric]A[utomatic]
LAS\SET WEIGHT type
LAS\SET WINDOW [w11 wu1 [w12 wu2 [...]]] -
                [/POLYGON [N] [filename1...filenameN] [/VAR array]]

```

SET QUALITY

```
LAS\SET QUALITY q
```

FIND will select only observations of quality better than Q (i.e. less than Q). When originally written, unless the real time acquisition system detected a severe problem, all observations have quality 0, a priori the best. The quality flag of an observation can be changed using the TAG command. See HELP TAG for the recommended quality scale.

SET RANGE

```
LAS\SET RANGE West East South North
```

FIND will select all observations with offsets in the specified range. Default is * * * *.

SET REDUCED

```
LAS\SET REDUCED d1 d2
```

FIND will select all observations with reduction dates between d1 and d2. Dates are specified as DD-*MMM*-*YYYY* (i.e. 14-JUL-1789). Default is * *.

SET SELECTION

The following SET Parameter commands affect data selection in FIND:

```

LAS\SET ANGLE Unit
LAS\SET LINE Name
LAS\SET FREQUENCY Freq
LAS\SET MATCH Tol
LAS\SET NOMATCH
LAS\SET NUMBER n1 n2
LAS\SET OBSERVED d1 d2
LAS\SET OFFSETS o1 o2
LAS\SET POSANGLE amin amax
LAS\SET QUALITY q
LAS\SET RANGE West East South North

```

```

LAS\SET REDUCED d1 d2
LAS\SET SCAN s1 s2
LAS\SET SOURCE name
LAS\SET SYSTEM Type [Equinox]
LAS\SET TELESCOPE Name
LAS\SET TYPE CONTINUUM or LINE or SKYDIP

```

SET SCAN

```
LAS\SET SCAN s1 s2
```

FIND will select all observations with Scan numbers between s1 and s2. The Scan number, attributed by the on-line acquisition system may be different from the observation number which is used by CLASS to refer to the observations. Default is * *.

SET SUBSCAN

```
LAS\SET SUBSCAN s1 s2
```

FIND will select all observations with subscan numbers between s1 and s2. The subscan number reflects the record number during an On-The-Fly acquisition. Default is * *.

SET SORT

```
LAS\SET SORT keyword
```

Defines the sorting when building the INDEX with FIND. The sorting is in ascending order. Default sorting is recovered with SET SORT NONE.

Keyword is one of:

```

BETA KIND LAMBDA LINE NUMBER NONE OBSERVED QUALITY SCAN SUBSCAN
SOURCE TELESCOPE VERSION

```

SET SOURCE

```
LAS\SET SOURCE name
```

FIND will select all scans according to the specified source name. Default is *. Wildcards are accepted at any position in the source name (e.g. NAM*, N*ME or N*M*): they match 0 or more characters.

SET SYSTEM

```
LAS\SET SYSTEM Type [Equinox]
```

Specify the coordinate system to be used. Type may be E[quatorial] followed by an epoch, G[alactic], or A[utomatic]. Default is Auto, i.e. us-

es the type found in the data file. If the equinox of Equatorial coordinates is not specified, the previous value is used. The initial default is 1950.00. Coordinates and offsets are automatically converted to the specified coordinate system and precessed to the specified epoch if needed.

SET TELESCOPE

LAS\SET TELESCOPE Name

FIND will select all scans according to the specified telescope name. Default is *. Wildcards are accepted at any position in the telescope name (e.g. NAM*, N*ME or N*M*): they match 0 or more characters.

SET TYPE

LAS\SET TYPE CONTINUUM or LINE or SKYDIP

Defines on which type of data the program is working.

- LINE (or SPECTROSCOPY) (the default when entering LAS) selects Spectral Line data only, and the program prompt is LAS> (Line Analysis System).
- CONTINUUM selects continuum drifts results only, and the program prompt changes to CAS> (Continuum Analysis System).
- SKYDIP selects only skydips, and the prompt changes to SAS>

In CONTINUUM mode, a continuum drift is treated as a spectrum would be in LINE mode. You can add drifts, subtract baseline, make gauss fits, change plotting scales etc... The current angular units is used in plots. SKYDIP mode has very limited capabilities: only command REDUCE may be used to analyse the SKYDIP results.

SET UNIT

LAS\SET UNIT Lower [Upper]

Specify the unit to be used for the lower and upper X axis. Allowed units are C[hannel], F[requency], [Image] and V[elocity]. Default is Velocity. For Continuum drifts, this unit is ignored, but the angular unit specified by SET ANGLE is used.

SET VARIABLE

LAS\SET VARIABLE Section_Name [Keyword]

Declare SIC variables corresponding to section of the header of the R observation. The header sections are POSITION, SPECTRO, BASE, HISTORY, PLOT, FSWITCH, CALIBRATION, SKYDIP, GAUSS, SHELL, NH3 (or HFS), DRIFT, BEAM, and CONTINUUM. Defining these SIC variables allows to access the header for mathematical computations using SIC facilities. All variables

are declared as readonly, unless Keyword WRITE is specified as third argument. If Keyword OFF is specified, the corresponding SIC variables are deleted (to save space since the total number of SIC variables is limited).

The SIC variables have the name of the corresponding FORTRAN variables stripped from the first character (always R in the FORTRAN code). They are defined below

GENERAL General parameters, always present:

```

INTEGER MGEN
INTEGER MGEN2
PARAMETER (MGEN=9,MGEN2=11)
INTEGER  RNUM          ! [      ] Observation number
INTEGER  RVER          ! [      ] Version number
INTEGER  RTELES(3)    ! [      ] Telescope name
INTEGER  RDOBS        ! [ day] Date of observation
INTEGER  RDRED        ! [ day] Date of reduction
INTEGER  RTYPEC       ! [ code] Type of coordinates
INTEGER  RKIND        ! [ code] Type of data
INTEGER  RQUAL        ! [ code] Quality of data
INTEGER  RSCAN        ! [      ] Scan number
REAL*8   RUT          ! [ rad] UT of observation
REAL*8   RST          ! [ rad] LST of observation
REAL*4   RAZ          ! [ rad] Azimuth
REAL*4   REL          ! [ rad] Elevation
REAL*4   RTAU         ! [neper] Opacity
REAL*4   RTSYS        ! [  K] System temperature
REAL*4   RTIME        ! [  s] Integration time

```

SECTIONS Information about present sections

```

LOGICAL PRESEC(-MX_SEC:0) ! [      ] List of present sections

```

POSITION Position information:

```

INTEGER MPOS
PARAMETER (MPOS=11)
INTEGER  RSOURC(3)    ! [      ] Source name
REAL*4   REPOCH      ! [ code] Epoch of coordinates
REAL*8   RLAM        ! [ rad] Lambda
REAL*8   RBET        ! [ rad] Beta
REAL*4   RLAMOF      ! [ rad] Offset in Lambda
REAL*4   RBETOF      ! [ rad] Offset in Beta
INTEGER  RPROJ       ! [ code] Projection system

```

SPECTRO Spectroscopic information (for spectra)

```

INTEGER MSPEC
PARAMETER (MSPEC=18)

```

```

INTEGER  RLINE(3)           ! [      ] Line name
REAL*8   RRESTF             ! [ MHz] Rest frequency
INTEGER  RNCHAN             ! [      ] Number of channels
REAL*4   RRCHAN             ! [      ] Reference channels
REAL*4   RFRES              ! [ MHz] Frequency resolution
REAL*4   RFOFF              ! [ km/s] Frequency offset
REAL*4   RVRES              ! [ km/s] Velocity resolution
REAL*4   RVOFF              ! [ km/s] Velocity at reference channel
REAL*4   RBAD               ! [      ] Blanking value
REAL*8   RIMAGE             ! [ MHz] Image frequency
INTEGER  RVTYPE             ! [ code] Type of velocity

```

BASE Baseline information (for spectra of drifts)

```

INTEGER  MWIND
INTEGER  MBASE
PARAMETER (MWIND=100,MBASE=4+2*MWIND)
INTEGER  RDEG               ! [      ] Degree of last baseline
REAL*4   RSIGFI             ! [      K] Sigma
REAL*4   RAIRE              ! [K.km/s] Area under windows
INTEGER  RNWIND             ! [      ] Number of line windows
REAL*4   RW1(MWIND)         ! [ km/s] Lower limits of windows
REAL*4   RW2(MWIND)         ! [ km/s] Upper limits of windows
REAL*4   WINDOW(FOUND,1+2*RNWIND) ! [ km/s] 2D plots: window for each reco

```

HISTORY Scan numbers of initial observations

```

INTEGER  MSEQ
INTEGER  MORIG
PARAMETER (MSEQ=100,MORIG=2*MSEQ+1)
INTEGER  RNSEQ              ! [      ] Number of sequences
INTEGER  RSTART(MSEQ)      ! [      ] Start scan number of seq.
INTEGER  REND(MSEQ)        ! [      ] End scan number of seq.

```

PLOT Default plotting limits.

```

INTEGER  MPLOT
PARAMETER (MPLOT=4)
REAL*4   RAMIN              ! [      ] Min Y value plotted
REAL*4   RAMAX              ! [      ] Max Y value plotted
REAL*4   RVMIN              ! [      ] Min X value plotted
REAL*4   RVMAX              ! [      ] Max X value plotted

```

FSWITCH Frequency switching information (for spectra)

```

INTEGER  MXPHAS
INTEGER  MFSW
PARAMETER (MXPHAS=8,MFSW=2+6*MXPHAS)
INTEGER  RNPHAS             ! [      ] Number of phases
REAL*8   RDECAL(MXPHAS)    ! [ MHz] Frequency offsets
REAL*4   RDUREE(MXPHAS)    ! [      s] Time per phase

```

```

REAL*4  RPOIDS(MXPHAS)      ! [      ] Weight of each phase
INTEGER  RSWMOD              ! [ code] Switching mode (frequency, position.
REAL*4  RLDECAL(MXPHAS)    ! [  rad] Lambda offsets
REAL*4  RBDECAL(MXPHAS)    ! [  rad] Beta offsets of each phase

```

CALIBRATION Calibration parameters

```

INTEGER  MCALIB
PARAMETER (MCALIB=21)
REAL*4  RBEEFF              ! [      ] Beam efficiency
REAL*4  RFOEFF              ! [      ] Forward efficiency
REAL*4  RGAINI              ! [      ] Image/Signal gain ratio
REAL*4  RH2OMM              ! [  mm] water vapor
REAL*4  RPAMB               ! [  hPa] Ambient pressure
REAL*4  RTAMB               ! [   K] Ambient temperature
REAL*4  RTATMS              ! [   K] Atmosphere temp. signal band
REAL*4  RTCHOP              ! [   K] Chopper temperature
REAL*4  RTCOLD              ! [   K] Cold load temperature
REAL*4  RTAUS               ! [ neper] Opacity signal band
REAL*4  RTAUI               ! [ neper] Opacity image band
REAL*4  RTATMI              ! [   K] Atmosphere temp. image band
REAL*4  RTREC               ! [   K] Receiver temperature
INTEGER  RCMODE             ! [ code] Calibration mode
REAL*4  RATFAC              ! [   K] Applied calibration factor (Tcal)
REAL*4  RALTI               ! [   m] Site elevation
REAL*4  RCOUNT(3)         ! [ count] Power of Atm., Chopp., Cold
REAL*4  RLCALOF             ! [   ?] Longitude offset for sky measurement
REAL*4  RBCALOF             ! [   ?] Latitude offset for sky measurement

```

SKYDIP For Skydips observations. No associated data.

```

INTEGER  MSKY
INTEGER  MSKYDIP
PARAMETER (MSKY=10,MSKYDIP=10+4*MSKY)
INTEGER  RSLINE(3)         ! [      ] Line name
REAL*8  RSREST              ! [  MHz] Rest frequency
REAL*8  RSIMAG              ! [  MHz] Image frequency
INTEGER  RNSKY              ! [      ] Number of points on sky
INTEGER  RNCHOP             ! [      ] - - - - chopper
INTEGER  RNCOLD             ! [      ] - - - - cold load
REAL*4  RELEV(MSKY)        ! [  rad] Elevations
REAL*4  REMISS(MSKY)       ! [   ?] Power on sky
REAL*4  RCHOPP(MSKY)       ! [   ?] Power on chopper
REAL*4  RCOLD(MSKY)        ! [   ?] Power on cold load

```

GAUSS Gauss fit results (for spectra or drifts)

```

INTEGER  MXGAUS
INTEGER  MFIT
PARAMETER (MXGAUS=5,MFIT=3+6*MXGAUS)

```

```

INTEGER  RNLINe           ! [           ] Number of components
REAL*4   RSIGBA           ! [ Int. unit] Sigma on base
REAL*4   RSIGRA           ! [ Int. unit] Sigma on line
REAL*4   RNFIT(3*MXGAUS) ! [area,v0,fwhm] Fit results
REAL*4   RNERR(3*MXGAUS) ! [area,v0,fwhm] Errors

```

SHELL "Stellar shell" profile fit results (for spectra)

```

INTEGER  MSHELL
PARAMETER (MSHELL=43)
INTEGER  RLSHEL           ! Number of components
REAL*4   RBSHEL           ! Sigma on base
REAL*4   RRSHEL           ! Sigma on line
REAL*4   RNSHEL(20)       ! Fit results
REAL*4   RESHEL(20)       ! Errors

```

NH3 "Ammoniac and Hyperfine Structure" profile fit results
(for spectra, ex: NH3, HCN)

```

INTEGER  MNH3
PARAMETER (MNH3=27)
INTEGER  RLNH3           ! Number of components
REAL*4   RBNH3           ! Sigma on base
REAL*4   RRNH3           ! Sigma on line
REAL*4   RNNH3(12)       ! Fit results
REAL*4   RENH3(12)       ! Errors

```

ABS "Hyperfine Structure" ABSORPTION profile fit results
(for spectra, ex: NH3, HCN)

```

INTEGER  MABS
PARAMETER (MABS=35)
INTEGER  RLABS           ! Number of components
REAL*4   RBABS           ! Sigma on base
REAL*4   RRABS           ! Sigma on line
REAL*4   RNABS(16)       ! Fit results
REAL*4   REABS(16)       ! Errors

```

DRIFT Continuum drift description (for drifts)

```

INTEGER  MCONT
PARAMETER (MCONT=16)
REAL*8   RFREQ           ! [ MHz] Rest frequency
REAL*4   RWIDTH          ! [ MHz] Bandwidth
INTEGER  RNPOIN           ! [           ] Number of data points
REAL*4   RRPOIN           ! [           ] Reference point
REAL*4   RTREF            ! [     ?] Time at reference
REAL*4   RAREF            ! [ rad?] Angular offset at ref.
REAL*4   RAPOS            ! [ rad?] Position angle of drift
REAL*4   RTRES            ! [     ?] Time resolution
REAL*4   RARES            ! [ rad?] Angular resolution

```

```

REAL*4  RCBAD           ! [      ] Blanking value
INTEGER RCTYPE         ! [ code] Type of offsets
REAL*8  RCIMAG        ! [  MHz] Image frequency
REAL*4  RCOLLA        ! [      ] Collimation error Az
REAL*4  RCOLLE        ! [      ] Collimation error El

```

BEAM Beam-switching parameters (for spectra or drifts)

```

INTEGER MBEAM
PARAMETER (MBEAM=5)
REAL*4  RCAZIM        ! [ ? rad] Azimuth of observation
REAL*4  RCELEV        ! [ ? rad] Elevation of observation
REAL*4  RSPACE        ! [ ? rad] Beam spacing
REAL*4  RBPOS         ! [ ? rad] Position angle of beams
INTEGER RBTYPE        ! [ code] System for angle

```

CONTINUUM Double gaussian and baseline fit results (for drifts)

```

INTEGER MFCONT
PARAMETER (MFCONT=19)
INTEGER RLCONT        ! Number of components
REAL*4  RBCONT        ! Sigma on base
REAL*4  RRCONT        ! Sigma on line
REAL*4  RNCONT(8)     ! Results
REAL*4  RECONT(8)     ! Errors

```

SET VELOCITY

LAS\SET VELOCITY mode

Mode is

```

L[sr]           Forces the velocity axis values to Lsr values
H[heliocentric] Forces the velocity axis values to Heliocentric values
A[automatic]    Reverts to the default mode where the velocity type is
                taken from the header of the spectrum.

```

SET VIRTUAL

LAS\SET VIRTUAL ON|OFF

LAS\SET VIRTUAL CHECK|NOCHECK

First command enables or disables the buffering of spectra read in CLASS. Default is ON.

A bug in this buffer handling was present from May2006 to Nov2008. See the news for Dec08 release at <http://www.iram.fr/IRAMFR/GILDAS/> for more details. Since occurrence was small and is difficult to predict, the second command enables or disables an error which is raised when the bug would have been encountered. This is intended to help users to decide if they should rerun or not the processing of their data with the latest CLASS releases where the bug is fixed. Default is NOCHECK.

SET WEIGHT

LAS\SET WEIGHT type

Weighting to be used for summations: T[ime], E[qual] or S[igma] (for $1/\sigma^{**2}$). The default is TIME. Sigma is not recommended unless you just made a baseline fit before. Equal weight behaves differently in AVERAGE/STITCH and ACCUMULATE (which produces the sum).

SET WINDOW

```
LAS\SET WINDOW [w11 wu1 [w12 wu2 [...]]] [/VAR array]
                [/POLYGON [N] [filename1...filenameN]]
                [/NOCURSOR]
```

Defines one or several line windows to be avoided by BASE when fitting a baseline. If available, the cursor will be used to specify missing arguments, unless option /NOCURSOR is present. When using the cursor, enter: N (or Left mouse button) to enter a value, C (or Middle button) to cancel the last entry, H for help, E (or Right button) for exit. The boundaries are in current unit. There is no default.

```
SET WINDOW /POLYGON [N] [filename1...filenameN]
```

Define the spectral window(s) through polygon(s). N is the number of polygons. If filenames are present, polygons are read from these files. If not, they are defined interactively with the cursor, and saved in files 'i'.pol, where 'i' is the number of the polygon.

```
SET WINDOW /VAR win_array
```

Define the window from rank 1 array win_array[1+2*NWIND]. The array must be of the following form:

```
win_array[1]=NWIND      number of windows
win_array[2*i:2*i+1]    boundaries of window num. 'i'
```

5.1.29 SHOW

LAS\SHOW Arg

Display some parameter defined by SET. Arg can be "ALL" to display all parameters specified by SET. See SET command. SHOW command is not stored in the stack of commands.

5.1.30 SPECTRUM

```
LAS\SPECTRUM [Yoff] [/INDEX] [/OBS]
```

/OBS

Plots the spectrum in the R buffer in the units and scales defined by SET UNIT and SET MODE. Yoff (default 0) is a constant Y-offset

added to the plotted values (useful to compare two spectra).

`/INDEX`

Plots the 2D array from the last `LOAD` command.

Without option, the behavior depends on `SET ACTION` (see `PLOT`). Default is `OBS`.

5.1.31 STITCH

`LAS\STITCH [/NOMATCH] [/RESAMPLE NX Xref Xval Xinc Unit]`

Stitch (i.e. make the union of) all the spectra of the current index using the current weighting function (see `SET WEIGHT`). The command behaves like `AVERAGE /RESAMPLE` except it ignores the `SET ALIGN` status and always composes the spectra on the frequency axis.

The homogeneity of calibration is checked according to `SET CALIBRATION`. Bad channels are handled according to `SET BAD`. A sum may be interrupted by `<^C>`, but the result is then undefined.

The position coincidence of consecutive spectra will not be checked if option `/NOMATCH` is present. Else, this check relies on the current `SET [NO]MATCH` status. See `SET MATCH` to build an index with a given positioning tolerance.

STITCH /RESAMPLE

`LAS\STITCH [/RESAMPLE NX Xref Xval Xinc Unit]`

Without this option, the X axis of the output sum will be automatically computed as the composition of all the input frequency axes. The output spectrum has the coarsest resolution of the input spectra. Those are then internally resampled and added on this new axis.

A custom output X axis can be given with the option `/RESAMPLE NX Xref Xval Xinc Unit`. The input spectra are internally resampled and added on this axis. The output resolution can not be better than the coarsest resolution of the input spectra to avoid oversampling.

5.1.32 SWAP

`LAS\SWAP`

Exchange the contents of the R and T buffers.

5.1.33 TAG

`LAS\TAG Quality_Code List_of_Observations`

Attributes a quality to a given list of Observations. Quality_Code is an integer in the range 0-9, and the recommended quality scale is

- 0 Unknown
- 1 Excellent
- 2 Good
- 3 Fair
- 4 Average
- 5 Poor
- 6 Bad
- 7 Awful
- 8 Should never exist
- 9 Reserved for deleted Observations

The operation is immediate and occurs in the OUTPUT file for all versions of all Observations specified in the list. If no list is given, the R memory is attributed the specified quality. A FIND operation will only select Observations of quality better than (i.e. less or equal to) the quality specified by the SET QUALITY command, or in the /QUALITY option.

5.1.34 TITLE

LAS\TITLE [/BRIEF] [/LONG] [/FULL] [/INDEX] [/OBS]

/OBS

Writes the header of the Observation currently in R above the plotted data. The format used is the one selected by SET FORMAT, which may be temporarily overridden by the options.

/INDEX

Writes the content of the loaded index in a compact form: Range of scan numbers, of spectrum, of observing dates and of offsets. It may be combined the other options (/LONG and /FULL give the same result).

Without option, the behaviour is fixed by SET ACTION level. Default is OBS.

5.1.35 UPDATE

LAS\UPDATE

Update the LAST version of the observation in the R buffer in the output file ; the update OVERWRITES the observation. If more space is needed (e.g., the new version has more header information), an error is returned. You MUST then WRITE the observation to avoid loss of information. You can update only last versions. This command MUST BE USED WITH CAUTION ; in case of complex manipulations of observations, you may get

confused and erase precious data.

The only typical case where it may be used is in the following sequence:

```
GET Number
MINIMIZE or MODIFY
UPDATE
```

5.1.36 WRITE

```
LAS\WRITE [Observation]
```

Writes the observation in the R buffer onto the output file. If a version of this observation is already in the file, a new version of the observation is created. A new observation number can be specified as argument. The information written depends on the operations done on the observation. Existing fit results are written. The calibration information is written only if the calibration is checked (see SET CALIBRATION command).

In the case of (old) on-the-fly data, WRITE automatically splits the data into records with entry numbers starting at 1 unless the observation number of the first record is given explicitly.

The behaviour depends on the "File Type" (see FILE command). For files of type MULTIPLE, a new version of the spectrum is written if the ObservationNumber already exists in the file.

For files of type SINGLE, the ObservationNumber is automatically set to the next one available in the file. If an ObservationNumber is specified in the command, WRITE checks if it already exists. If so, it returns an error; if not, it attributes the specified ObservationNumber to the written spectrum.

5.2 ANALYSE Language Internal Help

5.2.1 Language

ANALYSE\ Command Language Summary

(+ indicates a NEW command and - an obsolete command)

COMMENT	Manipulate the COMMENT section of spectra
-CUBE file [fnct]	Obsolete. Replaced by TABLE and MAP\XY_MAP
DIVIDE	Divide R spectrum by T spectrum
DRAW	Call the cursor or plot comments
FILL begin end	Fill from begin to end with noise, blank, etc.
FFT	Compute and edit Fourier Transform of R or P
GREG [name]	Make a TABLE or formatted file from current scan
-GRID	Obsolete. Replaced by TABLE and MAP\XY_MAP

+LMV	Convert a data cube into a set of spectra
MAP [M W]	Plot a map of spectra (or only their location)
MEMORIZE Arg	Memorize the current observation
MODEL Var	Generate a CLASS spectrum from a 1D variable
NOISE [S [NEW]]	Generate gaussian noise
PRINT [Arg]	Print values in a formatted file, or a table
POPOP	Zoom a spectrum from a STAMP or MAP plot
REDUCE	Reduce a SKYDIP
RESAMPLE Arg	Resample a spectrum on a specified grid
RETRIEVE Arg	Retrieve an observation from the memories
SMOOTH [Arg...]	Smooth the spectrum in R
STAMP	Display all spectra in index on one plot
STRIP File	Create an image for Position-Velocity plots
+TABLE	Build a GILDAS table from the current index

5.2.2 COMMENT

ANALYSE\COMMENT [READ|WRITE|APPEND|EDIT|DELETE] ["comment"]

This command READs, WRITEs or DELETEs an existing comment section (max. length: 1020 characters) of the current R buffer.

READ	display the comment section
WRITE	write (or append) the input comment given between double quotes.
EDIT	write a comment given interactively
DELETE	delete and reset the comment section
APPEND	Obsolescent

5.2.3 CUBE

ANALYSE\CUBE Filename [MATH_EXPRESSION] [/CHANNEL Cmin Cmax] [/STEP Stepx Stepy]

Obsolete. Replaced by ANALYSE\TABLE and MAP\XY_MAP

5.2.4 DIVIDE

ANALYSE\DIVIDE Threshold

This command divides the spectrum in R by the spectrum in T, which is left unchanged. The two spectra must be on the same velocity scale (Use command RESAMPLE to do so). Threshold is a value to avoid zero divide. The output spectrum is blanked for channels where $\text{abs}(T) < \text{Threshold}$.

5.2.5 DRAW

ANALYSE\DRAW [Action [Parameters]]

This command executes the specified drawing action, or calls the graphic

cursor and uses the returned character from the cursor to execute the corresponding action. The mnemonic for the cursor characters are :

F for "FILL" To interpolate a bad channel
 K for "KILL" To flag a bad channel
 L for "LOWER" To flag line identifications, ...
 M for "MASK" To show active masks
 T for "TEXT" To annotate your spectrum
 U for "UPPER" Similar to LOWER
 W for "WINDOW" To show current line windows

any other to display the channel number, frequency, velocity and antenna temperature at the cursor position. The explicit form does not call the cursor and can be used in procedures.

DRAW FILL

ANALYSE\DRAW FILL Nchan

Interpolates the value of the specified bad channel using the nearest valid channels. Channel Nchan must be blanked before. In cursor mode, the channel number is retrieved from the cursor position.

DRAW KILL

ANALYSE\DRAW KILL Nchan

Deletes the specified channel, i.e. attributes the blanking value to it. In cursor mode, the channel number is retrieved from the cursor position.

DRAW LOWER

ANALYSE\DRAW LOWER value "text" [angle]

Draws a vertical line with label "text" (written vertically by default, or with orientation 'angle' in degree) at abscissa 'value' in lower axis unit. The line length is adjusted to approach closely the spectrum value at the corresponding abscissa.

DRAW MASK

ANALYSE\DRAW MASK [level]

Plots the active masks, with bars at the mask positions and Y=Level (Default 0).

DRAW MOLECULE

ANALYSE\DRAW MOLECULE frequency name [angle]

Display a molecule name at the given frequency (irrespective of the units from the SET UNIT command), with a given orientation (angle, default 90). The name lies on the lower X-axis.

frequency	Frequency in MHz of the line
name	String giving the name to be written
angle	Orientation, in degree, with respect to X-axis

DRAW UPPER

```
ANALYSE\DRAW UPPER Value "text" [angle]
```

Draws a vertical line with label "text" (written vertically by default, or with orientation 'angle' in degree) at abscissa Value in upper axis unit. The line length is adjusted to approach closely the spectrum value at the corresponding abscissa.

DRAW TEXT

```
ANALYSE\DRAW TEXT X Y "text" I
```

Writes (horizontally) the string "text" at plot position (X,Y) in paper units, with the centering code I for the string.

DRAW WINDOW

```
ANALYSE\DRAW WINDOW [Yup] [Ylow]
```

Plots the current line windows, with bars. Ylow and Yup refer to the bottom and upper levels of the bars.

5.2.6 FFT

```
ANALYSE\FFT [/REMOVE [wmin wmax]]
           [[s1 e1] [s2 e2] ... [s10 e10] /KILL]
           [/INDEX] [/OBS] [/NOCURS]
```

FFT computes a Fourier Transform and plots it. It acts either on a single spectrum (from the R buffer) or on the INDEX. The default behavior is defined with SET ACTION, but can always be ignored with /OBS or /INDEX. Identically, the option /NOCURS overrides the default cursor. /KILL allows to linearly interpolate the fourier transform, either interactively or by supplying values. The /REMOVE option indicates that the fourier transform is to be computed from a spectrum linearly interpolated in some intervals (specified or taken from the last fitted profiles). R and T observations are unaffected.

FFT /KILL

```
FFT [[s1 e1] [s2 e2] ... [s10 e10] /KILL]
```

Perform a linear interpolation (on real and imaginary parts) on the fourier transform. The intervals are defined interactively (if no value supplied and the cursor is available) or not (if values in MHz-1 are supplied).

FFT /REMOVE

```
ANALYSE\FFT /REMOVE [wmin wmax]
```

If no value supplied, the sum of existing fits of the current method is subtracted before computing the Fourier transform. If an interval is supplied, linearly interpolate between wmin and wmax.

5.2.7 FILL

```
ANALYSE\FILL s1 e1 [[s2 e2] ...] [/INTER] [/NOISE [rms]] [/BLANK [bval]]
```

Performs the specified action in the interval(s) specified with starting and ending values (in current units).

/INTER

Makes a linear interpolation. When combined with **/NOISE [rms]**, a Gaussian noise is added to the linear interpolation.

/NOISE [rms]

Fill in the interval(s) with a Gaussian noise of a given rms. This option can be combined with **/INTER**.

/BLANK [bval]

Fill in with blank value unless bval is specified.

5.2.8 GREG

```
ANALYSE\GREG Name [/FORMATTED] [/READ [X n] [Y m]]
```

Writes in file Name the contents of current scan as a GILDAS table, or as a formatted file if the **/FORMATTED** option is present.

If the **/READ** option is present, performs the reverse operation: load the file content in the current scan. Only available for formatted files; the equivalent capability for GILDAS tables is available through a combination of **DEFINE IMAGE** and **MODEL**.

For the table, the information stored is :

1. Intensity
2. Channel number
3. Velocity

4. Offset frequency
5. Rest frequency
6. Image frequency
7. Fitted profiles if any - fit(i),i=0,nline - in column 7+i

The output table can be put later in a formatted way using GILDAS task LIST in you need.

The table may be used as input to GreG to produce fancy plots, or by the GILDAS software for other applications. In particular, SIC variables can be used to subtract any of the fits from the spectrum to produce residuals if needed. For plots, note that you can produce essentially the same within CLASS, except under very special circumstances, and moreover that only CLASS can handle the different X-unit simultaneously.

For the formatted list, less information is written (and it takes longer to write it of course) :

1. Current X unit in column 1
2. Intensity in column 2
3. Fitted profiles - (fit(i),i=0,nline) - in column 3+i

For the /READ option, columns are X 1 Y 2 by default but can be changed. If X 0 is given as zero, then only Y is read and X is filled with channel numbers. Only very coarse header information is filled in. A lot of complementary header editing will often be needed.

5.2.9 GRID

```
ANALYSE\GRID [Filename] [NEW|APPEND] [MATH_EXPRESSION]
[/CHANNEL [C|V|F|I] min max]
[/IMAGE [BEAM beam] [LAM nx rx vx ix] [BETA ny ry vy iy] [LIKE temp-
file]]
[/PLOT [where]]
```

Obsolete. Replaced by ANALYSE\TABLE and MAP\XY_MAP

5.2.10 LMV

```
ANALYSE\LMV Filename [/SCAN LAMDBA|BETA] [/STEP DLAMBDA [DBETA]]
```

Read the spectra cube stored in input Filename and convert it in a set of spectra automatically written in the currently opened output file. The spectra cube can be ordered in LMV, VLM, LVM, etc... FITS files are automatically converted.

By default, the command sorts the spectra to mimic the scanning path of a telescope along the lambda direction, shifted on beta for each scan. Each constant beta row has a unique SCAN number. The sorting can be ro-

tated by 90 degree by using the /SCAN BETA option.

Fully blanked spectra in the input cube are ignored. If the cube spatial axes are largely oversampled, the /STEP option allows the user to select 1 spectrum every DLAMBDA (resp. DBETA) in the LAMBDA direction (resp. BETA). If DBETA is omitted, it defaults to DLAMBDA. The default value of DLAMBDA and DBETA (if the /STEP option is not invoked) is 1, implying a conversion of the whole cube.

User should take care that many parameters of the CLASS spectrum headers have no meaning here. They are left to their default values.

5.2.11 MAP

```
ANALYSE\MAP [Match|Where|Keep] [/CELL Size_X [Size_Y]] [/GRID] [/NO-
LABEL] [/NUMBER]
```

Makes a map of spectra or display the true locations of the spectra. Offset limits are automatically computed, and it adjusts the size of a spectrum depending in the current box size. If not in WHERE-mode, the only constraint of MAP in this mode is that the X and Y limits must be fixed so that the spectra share a common scale.

MATCH

To force matching the X to Y ratio, which is otherwise adjusted so as to make the largest possible drawing. The options control presentation details.

WHERE

Only displays the spectra locations with crosses (the marker can not be modified). Can be combined with MATCH. Global variables `idx%loff` and `idx%boff` contains offsets positions of all entries of the current index, and may also be used, with GREG1\ commands (`g\limit`, `g\box`, `g\point`), to display the spectra locations. In this case, the marker can be modified (`g\set marker`).

KEEP

Will not recompute the grid. Uses the last grid. Can be useful for online display.

The actual graphic output is delayed until the end of the index has been reached. This process may be slow on some implementations and graphic terminals when the number of spectra is large. The MAP command can be interrupted by typing Control-C.

MAP /GRID

```
ANALYSE\MAP/GRID
```

A grid is plotted to separate the spectra.

MAP /CELL

```
ANALYSE\MAP/CELL Size_X [Size_Y]
```

If the option /CELL is given, the cell size of the grid is taken to be Size_X by Size_Y (default Size_X) current angular units. Spectra always fill the cells.

MAP /NOLABEL

```
ANALYSE\MAP/NOLABEL
```

If the option /NOLABEL is present, the coordinates are not written but ticks are still present. Tick can be suppressed by specifying a tick size of zero in command SET TICK.

MAP /NUMBER

```
ANALYSE\MAP/NUMBER
```

If the option /NUMBER is present, the observation number is written for each spectrum in the upper left corner.

5.2.12 MEMORIZE

```
ANALYSE\MEMORIZE [Name] [/DELETE]
```

If a Name is specified, put a copy of the current observation in a "memory" called Name. The observation can later be retrieved using command RETRIEVE. If no Name is specified, list the currently defined memories. Up to 100 memories can be defined at a time.

MEMORIZE Name /DELETE can be used to delete the "memory" area.

5.2.13 MODEL

```
ANALYSE\MODEL Y_Variable [X_Variable] [/BLANK Bval] [/REGULAR [Xref
Xval RestFreq]] [/FREQUENCY LineName RestFreq] [/XAXIS Xref Xval Xinc
Unit]
```

Generates a CLASS spectrum from a 1D SIC variable. Note that the 1D variable can be (and frequently is) a subset of a higher dimensionality variable. This command is typically used either to generate test data, or more frequently to transfer data from a GILDAS image (or cube) to CLASS.

A second variable, if present, is interpreted as an associated X axis scale for a presumably non linear or irregularly sampled frequency axis, as can occur for non resampled data from AOS backends (or optical spectra). Please note however that non linear axes are a largely untested feature in CLASS, you should avoid this solution when possible.

There are three (exclusive) ways to define the X axis: provide a X array, /XAXIS option, /REGULAR option (see below). The model header will have a minimal values set. On the other hand, if none of these three is used, the command will copy RX and header from the previous R buffer in memory.

/BLANK Bval

Allow the user to provide the blanking value. Default is -1000.

/REGULAR [Xref Xval RestFreq]

Indicate that data are regularly spaced along the X axis. If no reference pixel and value at reference are supplied, default values are set to respectively half the channel number and to the velocity in the nearest channel.

/FREQUENCY LineName RestFreq

Indicate line name and the rest frequency. Default rest frequency is 3.10^5 MHz.

/XAXIS Xref Xval Xinc Unit

Define the X axis with its reference channel (Xref), its value at reference channel (Xval), and the increment per channel (Xinc). Units are km/s or MHz if Unit is VELOCITY or FREQUENCY respectively. If Unit is FREQUENCY, Xval is expected to be the rest frequency.

5.2.14 NOISE

ANALYSE\NOISE [S [NEW]]

Generates and draws a spectrum with only gaussian noise of rms S, to be compared with actual receiver noise. S defaults to the rms of the current spectrum. If argument NEW is present, the spectrum is not plotted but the R buffer is copied in T, and the generated noise put into the R buffer.

5.2.15 POPUP

ANALYSE\POPUP Number

or

ANALYSE\POPUP OffX OffY

POPUP Number will display a separate window containing a complete plot

of an observation specified by number, if it has been previously displayed by a command STAMP or MAP.

POPUP OffX OffY will display a separate window containing a complete plot of an observation with offsets matching OffX and OffY, which has been previously displayed by a command MAP. If more than one observations have the same offsets, only the first one will be displayed.

In both cases, POPUP assumes that the index has not been modified since the last STAMP or MAP command.

POP with argument will active the cursor to select interactively the observation to be displayed. Point the cursor to its spectrum in the MAP or STAMP display and press P or click the mouse second button. Use the third button or E to exit the cursor mode. The first button or any key will display the offsets or observation number.

5.2.16 PRINT

ANALYSE\PRINT [Arg] [/OUTPUT File] [/TABLE File]

PRINT enables one to list some parameters in a GreG compatible format. Arg is an optional argument to precise what to print :

FIT Results of profile fits in current method

The information written is (1) the number of lines fitted, (2) the observation number, (3,4) the offsets in current angle units, (5,6,...) fit results of the current method in the same order as in DISPLAY command. For the Gauss Method, this order is: (5) Line Area, (6) its uncertainty (7) Position (8) incert. (9) Width (10) incert. (11) Intensity (12) Base RMS (13) Line RMS.

AREA Integrated area computed by BASE

The information written is (1) the observation number, (2,3) the offsets in current angle units, (4,5) Area and rms noise.

AREA v1 v2 v3 ... Area in velocity ranges

Area in velocity ranges v1 to v2 and v2 to v3, ... etc. The information written is (1) the observation number, (2,3) the offsets in current angle units, (4,5,...) the areas.

CHANNEL List List of channels

The list in the same format as the FOR-NEXT loop. Up to 15 channels at a time may be listed. The information written is (1) the observa-

tion number, (2,3) the offsets in current angle units, (4,5,...) the channels value.

MOMENT m1 m2 ... Moments of the observations

The moments (area, mean velocity, width) are computed in the intervals [m1,m2] [m3,m4] etc... Current unit is used. The information written is (1) the observation number, (2,3) the offsets in current angle units, (4,5,6) area, position, width, (7,8,9) etc...

POINTING Pointing fit results

Results of CONTINUUM method fit are printed in a format adapted to pointing constants measurements. The information written is (1,2) The observation and scan number, (3) a code for scan direction, (4,5) Azimuth and Elevation in degrees, (6) Time in hours, (7,8) Collimation and error along drift direction, (9,10) the antenna number and station code, (11,12) Width and error, (13,14) Intensity and rms noise, (15) Source name.

FLUX Flux measurements results

Results of CONTINUUM method fits printed in a format adapted to flux measurements. The information written is (1,2) The observation and scan number, (3) a code for scan direction, (4,5) Azimuth and Elevation in degrees, (6) Time in hours, (7,8) Position and error along drift direction, (9) the antenna number, (10,11) Width and error, (12,13) Intensity and rms noise, (14) Image gain ratio, (15,16) Signal and Image frequencies, (17) Source name, (18) Observing date.

/OUTPUT File

Write the results in a formatted file named File instead of on the screen. The file is suited for later processing by GreG, in particular for contour maps.

/TABLE File

Write the results in a table named File. This table can also be accessed by GreG, in a much faster (50 times) way than a formatted file. Tables can also handle many more columns than formatted files, and they are not limited in precision by the formatting. Mathematical operations can be done directly on the table columns. However the FIT results cannot be written to a table.

5.2.17 REDUCE

ANALYSE\REDUCE

This command reduces a SKYDIP observation, by fitting the sky emission

using atmospheric parameters written in the observation, and displays the results : Water vapor content and Telescope Forward Efficiency

5.2.18 RESAMPLE

```
ANALYSE\RESAMPLE NX Xref Xval Xinc UNIT [shape] [width] [/FFT]
```

This command resamples a given spectrum on a specified X axis in given unit. The arguments are:

- NX the number of channels desired
- Xref the new reference channel
- Xval the value at the reference channel
- Xinc the new channel separation
- UNIT either CHANNEL, VELOCITY or FREQUENCY to indicate the units used for Xval and Xinc.
- SHAPE (optional) a keyword for the frequency response of the synthesized channels:
 - TBOX means a rectangular function in the delay domain, as for unsmoothed correlator channels ($\sin(\pi.x)/(\pi.x)$ in the frequency domain)
 - TPAR means a parabolic function in the delay domain, as for smoothed correlator channels (smoothing function used at Plateau de Bure)
 - FBOX means a rectangular function in the frequency domain (as for filterbank channels)
 - FTRIANGLE means a triangular function in the frequency domain (as for filterbank channels, Hanning smoothed)

By default the shape of the output channels is the same as the shape of the input channels.

- WIDTH (optional) the width of the output channels in units of the channel separation. The default (and minimum value) is 1.

/FFT

The resampling is done in the delay domain and the data are Fourier transformed. The Fourier transform is divided by the transform of the input channel shape, then extrapolated by zeroes (if interpolation in the frequency domain is required), multiplied by the transform of the desired channel shape, and finally transformed back to frequency domain. The output channel separation usually needs to be slightly rounded (to enable use of the FFT, the input spectrum must contain a round number of output channels). To obtain an exact channel separation, the NOFFT option is necessary.

The WIDTH parameter is used to provide an oversampled output spectrum if needed.

The shape of the input channels is derived from the backend number read in the telescope name for IRAM-30m spectra: TBOX for autocorrelator,

FBOX for other (filter) backends. Otherwise, rectangular filter channels are assumed.

5.2.19 RETRIEVE

ANALYSE\RETRIEVE Name

Retrieve the observation in memory "Name" and copy it in the R observation.

5.2.20 SMOOTH

ANALYSE\SMOOTH [Arg...]

SMOOTH copies R into T, then degrades the frequency/velocity resolution of R. The arguments are used to specify the method :

- HANNING (default)
The new spectrum has twice less channels and twice less resolution.
- AUTO
Uses a cross-validation smoothing with automatic choice of smoothing parameter. To be used with caution. Noise in adjacent channels must be independant, otherwise the algorithm flatly refuses to do any smoothing at all (but needs a long computing time to realise that...).
- GAUSS Width
Convolve (by multiplication in the Fourier plane) by a gaussian of specified width in current units.
- BOX Ncan
Averages Ncan adjacent channels to produce a spectrum with Ncan less resolution and channels.
- NOISE Flux Nc
For each channel, sums at most Nc neighbouring channels until a total flux Flux is reached in the sum. Then attributes the average value (sum divided by number of channels added) to the channel. This smoothing is non-uniform, strictly positive, and has an obvious tendency to produce wings...

5.2.21 STAMP

ANALYSE\STAMP NX [NY] [/NUMBER]

This command is intended to have a quick look at all the observations in the index. It makes a plot of all the observations in the index, arranged in a "map" of NX by NY observations. (If the index contains many observations, they will be very small, hence the name of the command).

The option `/NUMBER` writes the number of each observation in the upper left part of its box. The command does not require that X and Y scales be fixed.

Command `POPUP` allows a selective zooming of any observation displayed by command `STAMP`.

5.2.22 STRIP

ANALYSE\STRIP File

STRIP creates a GILDAS 2-D image which can be used later by GILDAS to produce Velocity-Position plots using command `RGMAP`. STRIP works on the current index, and checks that it defines a true strip along one of the main directions ; that means you should have build the current index with `FIND/OFFSET Value *` or `FIND/OFFSET * Value`. The current X unit is used. The name of the output file must be given.

To produce a strip along another direction than X or Y, change the offsets of your spectra using command `MODIFY OFFSETS`, and write the modified spectra in a new output file.

STRIP can also produce a GILDAS 2-D image from a set of parallel continuum drifts. The drifts must have the same steps, and be regularly spaced. The index must define a coherent map.

PV cuts might also be done easily in GREG from a GILDAS table or cube with more versatility.

5.2.23 TABLE

```
ANALYSE\TABLE Filename [OLD|NEW] [/MATH Expression] [/RANGE rmin
rmax unit] [/RESAMPLE nc ref val inc unit [shape] [width]] [/FFT] [/FRE-
QUENCY name rest-freq] [/NOCHECK [SOURCE|POSITION|LINE|SPECTROSCOPY]]
```

Build a GILDAS table from current index entries. No gridding is done. This table may be then regridded on a Regular Grid to build a datacube for further use in GREG.

```
OLD      Append to table 'filename'
NEW      Create a new table
```

```
/MATH
```

Compute a mathematic expression instead of storing a spectrum. See subtopic `FUNCTIONS` for a list of available functions.

```
/RANGE
```

By default, the whole X axis is stored in the GILDAS table. A range can be imposed, in which case the unit must be specified.

/RESAMPLE

By default, the spectra are resampled, on-the-fly while building the TABLE, on the first spectrum X axis. This option allows to enforce that resampling is done on the given X axis.

/FFT

To specify that resampling is done in time domain.

/FREQUENCY

To change the line name and/or the rest frequency.

/NOCHECK

By default, the consistency of the index is checked against SOURCE, POSITION, LINE and SPECTROSCOPY parameters (see LAS\CONSISTENCY) before building the table. If the SPECTROSCOPY section appears inconsistent, the spectra are resampled on-the-fly on the first spectrum X axis. Other sources of inconsistency are not recoverable and the table is not built. This option without keyword allows to disable all consistency checks. With keyword(s), disable the corresponding checks.

Warnings:

1. /MATH, /RANGE and /RESAMPLE are exclusive
2. Continuum data not supported

TABLE FUNCTIONS

The Following Functions are defined:

STDV(dummy) returns the integrated area (K.Km/s) of the current spectrum

TPEAK(dummy) returns the Peak temperature (K) of the current spectrum

VPEAK(dummy) returns the Velocity at Peak (Km/s) of the current spectrum

TDV(v1,v2) returns the integrated area (K.Km/s) of the current spectrum between velocities V1 and V2

TPEAKV(v1,v2) returns the Peak temperature (K) of the current spectrum between velocities V1 and V2

VPEAKV(v1,v2) returns the Velocity at Peak (Km/s) of the current spectrum between velocities V1 and V2

To create a table containing the integrated area of your spectra, type:
TABLE Filename /MATH STDV(0)

5.3 FIT Language Internal Help

5.3.1 Language

FIT\ Language Summary

DISPLAY	Prints the results of the profile fit of R.
VISUALIZE [N]	Plots the current fitted profile.
MINIMIZE	Performs a profile fit.
ITERATE	Iterates the profile fit.
KEEP	Saves Gaussian fit results in the output file.
LINES [N]	Enters the initial values for the profile fit.
METHOD Arg	Selects the line profile for fits.
RESIDUAL [n]	Computes the residuals of the profile fit.

5.3.2 DISPLAY

FIT\DISPLAY [Yoff] [/NOPLOT] [/METHOD]

Prints the results of the profile fit of R for the current method. For the Gauss (default) method (see HELP METHOD), the command displays (1) the Line number, (2) the Area, (3) the Position, (4) the Width and (5) the Intensity, each with their associated errors, and resulting RMS in the Base and Line windows. Yoff indicates the Y offset for the results to be printed. Default value is 0.

/NOPLOT: if present, print the fit result but do not display them on the plot.

/METHOD: if present, print the fit result for the corresponding method.

5.3.3 ITERATE

FIT\ITERATE [N]

ITERATE tries the GRADIENT technique to improve the last results of the profile fit. Optional argument N indicates the number of iterations. Do not expect spectacular results if the absolute minimum is far away! Typically, this command should be used if the previous fit did not converge, but seems close enough. If you are using the GAUSS method, be cautious not to change the X unit in the mean time.

5.3.4 KEEP

FIT\KEEP

Save profile fit results in the output file. KEEP is equivalent to UPDATE, but only profile fit results are saved; KEEP is subject to the same restrictions as UPDATE.

5.3.5 LINES

```
FIT\LINES [N] [/NOCURSOR] [/INPUT File_Name]
```

Enter the initial values for the profile fit. If argument "AUTO" is given instead of a number, then the number of lines found in the last read spectrum will be used for ITERATE command.

If N is not specified, then the last value for N is used. If N is 0, MINIMIZE will attempt to guess initial values for a single line by computing the moments of the spectrum. If N is not 0, LINES prompts for the initial values for line parameters. N is limited to 5. These values should be separated by spaces and can be entered as SIC expressions as follows:

Method	Code,Value	Code,Value	Code,Value	Code,Value
GAUSS	Temperature	Position	Width	
SHELL	Area (K.MHz)	Offset (MHz)	Width (MHz)	Horn/Center
NH3	Temperature	Position	Width (MHz)	Opacity
HFS	Temperature	Position	Width (MHz)	Opacity

The code is an integer interpreted as follows :

- 0 adjustable parameter
- 1 fixed parameter
- 2 adjustable parameter (head of group)
- 3 parameter fixed with respect to parameter coded 2 or 4
- 4 fixed parameter (head of group)

Codes 2 3 and 4 are used to fit dependent lines (e.g. HCN, for which the displacements are 4.842 and -7.064 km/s, or -1.431 and 2.088 MHz, and line ratios 1:0.6:0.2). Codes 0 and 1 only are allowed for NH3 method. The value for a parameter with code 3 should be either the ratio to the head of group value (for both intensity and width), or the offset from head of group (for the position).

If the cursor is available, you will have to define the boundaries of the N lines. The program then computes the moments of the spectra between these boundaries as input values. You cannot change the codes in this way which is meaningful ONLY FOR FREE and INDEPENDENT lines. This cursor selection is not used if you specify the /NOCURSOR option.

Guesses can be read from an input file using the /INPUT File_Name option. "Free" format is used to read in this input file. The first line must contain the number of lines, others are as the input at the keyboard.

Command LINES is not supported for method CONTINUUM.

5.3.6 METHOD

FIT\METHOD Arg [Parameters ...]

Select the line profile for fits. Five type of profiles are available.

- GAUSS Select gaussian profiles.
Up to 5 Gaussian, dependent or independent can be fitted in a spectrum, according to command lines. Variables are Area Velocity and Width (FWHM).
- SHELL Horn-type profiles for Circumstellar Shells.
Variables are 1) Area [K.MHz] 2) Center offset [in MHz] 3) Full Width at zero level, and 4) Horn-to-center ratio (-1 for parabolic optically thick lines, 0 for flat-topped lines, Infinity for perfectly double peaked lines). Profiles are symmetric. Up to 5 dependent or independent lines may be fitted. X axis must be frequency.
- NH3(1,1) or NH3(2,2) or NH3(3,3)
Compute ammonia line profiles, with the assumptions of gaussian velocity distribution and equal excitation temperatures. Variables are 1) Main group opacity times (Excitation temperature minus Background temperature), 2) Velocity, 3) Width, and 4) Main group opacity. Up to 3 independent lines may be fitted, but it may be slow...
- HFS FileName for HyperFine Structure
This is very similar to the NH3 method, but the coefficient to describe the hyperfine structure are read in the file FileName. The first line of this file must contain the number of hyperfine components (< 40). The other lines must contain, for each component, the velocity offset and the relative intensity. The parameters are the same as for NH3 method.
- CONTINUUM for Continuum drifts.
Fit a single gaussian and a linear baseline at the same time, with automatic determination of the parameters. Uses beam-switched information for two-component fitting if required. The command METHOD CONTINUUM accept additional arguments, which can be used to customize the fit.

METHOD CONTINUUM [Width [Area_Ratio [Width_Ratio]]]

where

- Width is the width of the beam in arc seconds. By default, Width is a free parameter.
- Area_Ratio is the reference to main beam area ratio, used for beam-switch observing. By default, Area_Ratio is 1.
- Width_Ratio is the reference to main beam width ratio, used for beam-switch observing. By default, Width_Ratio is 1.

A * can be used instead of a numerical value for each parameter, and indicates that the parameter is free.

Note that in command `LINES`, one enters the peak line antenna temperature instead of the first variable in the guesses, except for `SHELL` method. Command `LINES` has no effect for `CONTINUUM`.

`CONTINUUM` and `GAUSS` methods only are relevant for continuum data, while `GAUSS`, `SHELL`, `NH3` and `HFS` methods can be used for spectroscopic data.

5.3.7 MINIMIZE

`FIT\MINIMIZE`

Performs a fit of a theoretical profile in the `R` spectrum using initial values specified by the command `LINES`. The profile is determined by the `METHOD` command (`GAUSS`, `SHELL` or `NH3` lines are currently implemented, and a special method, `CONTINUUM`, may be used for continuum data).

`MINIMIZE` performs the fit only on the part of the spectrum selected by `SET MODE X`. It also ignores the regions under the masks defined by `SET MASK`.

If `LINES` is 0, an attempt to guess initial values for a single line is done by computing the moments of the spectrum. A first minimisation is performed using the Simplex technique; the results are improved and the uncertainties computed using the Gradient technique. If `MINIMIZE` did not converge, the errors quoted in the results are meaningless, and you should use command `ITERATE` to try to do better.

For `CONTINUUM` method, although a linear baseline is fitted with the gaussian, only the gaussian parameters are displayed. If the observation was made using beam-switching method and the reference beam appears in the drifts, a two-component gauss fit is done using separation specified in the data.

5.3.8 RESIDUAL

`FIT\RESIDUAL [n]`

Compute the residuals of the last `MINIMIZE` fit. Copies `R` into `T`, then subtract the line profile number `N` from the spectrum in `R`. If `N` is 0, the sum of all components is subtracted.

5.3.9 VISUALIZE

`FIT\VISUALIZE [N] [/PEN [i]]`

Plot the current fitted profile. The `N`th line obtained the last time `MINIMIZE` was executed, or recovered by `DISPLAY`, is plotted on the screen. If `N` is 0, the sum of all lines is plotted, and if `N` is not giv-

en, the last value of N is used.

`/PEN [ipen]`: if ipen is present, use the given pencil 'ipen' properties (defined with "pen ipen"), otherwise use the last defined pencil. Without option, use pencil 2 properties.

5.4 MAP Language Internal Help

5.4.1 Language

<code>APODISE</code>	Apodization
<code>DECONVOLVE</code>	Deconvolve
<code>XY_MAP</code>	Build an LMV spectra cube from an XY table

5.4.2 APODISE

`MAP\APODISE`

Not yet available. Work in progress.

5.4.3 DECONVOLVE

`MAP\DECONVOLVE`

Not yet available. Work in progress.

5.4.4 XY_MAP

`MAP\XY_MAP [FilenamePrefix] [/NOGRID]`

Build an LMV spectra cube and an associated weight image from an XY table. The LMV cube (.lmv), WEI image (.wei) and XY table (.tab) share the same file name, given without extension. By default, data is grided with a convolution (general case), unless `/NOGRID` option is invoked (typically when the data is already regularly placed).

By default, the spatial grid of the LMV cube will be large enough to use all the spectra of the XY table. The pixel size will ensure Nyquist sampling (i.e. at least 2 pixels per beam). The grid position reference and position angle will be taken from the XY table header. The convolution kernel is a Gaussian of size one-third the telescope beamwidth, the convolution being computed on a limited support (large enough to ensure excellent accuracy).

However, the gridding process may be finely tuned through user defined values of the MAP structure. The header of an existing LMV cube may be used as a template for the grid definition. To do this, the user must set the `MAP%LIKE` variable to the template filename. When `MAP%LIKE` is set

to an empty string, the user may define the grid by hand through the following parameters

MAP%CELL	[arcsec]	X and Y pixel size
MAP%SIZE	[pixel]	X and Y map size
MAP%ANGLE	[degree]	Grid position angle
MAP%RA	[HH:MM:SS]	Grid reference position
MAP%DEC	[+DDD:MM:SS]	Grid reference position
MAP%SHIFT	[logical]	Shift and/or Rotate grid?

The natural beamwidth of the telescope is set in order of precedence by

MAP%BEAM	[arcsec]	The beam size
MAP%DIAM	[m]	The telescope diameter (if MAP%BEAM = 0)
MAP%TELE	[string]	The telescope name (if MAP%BEAM = MAP%DIAM = 0)

Because of the convolution, the spatial resolution of the grided data will by default be 5.4% wider than the telescope beamwidth at the observation frequency. It is however possible to grid the data with a wider Gaussian in order to smooth the data (e.g. to increase the signal-to-noise ratio of extended emission). The user have to define the required resolution of the grided data through

MAP%RESO	[arcsec]	Final resolution of the grided data (default is
----------	-----------	---

the command will deduce the size of the gridding kernel from the telescope beamwidth and the required resolution.

It is advised to avoid changing the following more technical parameters. However those parameters are tunable through

MAP%COL	[integer]	Range of columns to grid
MAP%WCOL	[integer]	Column of weights
MAP%CTYPE	[integer]	Convolution kernel type
MAP%SUPPORT	[arcsec]	Convolution kernel support size

For ease of use, a sensible value of each gridding parameter will automatically be computed from the context if the value of the corresponding MAP structure component is set to its default value, i.e. zero value and empty string. The only exception is the position reference and/or position angle of the grid: Changing them requires in addition to set MAP%SHIFT to YES.

XY_MAP /NOGRID

```
MAP\XY_MAP [Filename] /NOGRID
```

XY_MAP /NOGRID builds an LMV spectra cube and an associated weight image

from an XY table, but does not regrid the data with a convolution. The command assumes that it will encounter points which are regularly spaced, and that it can deduce from these the typical parameters of the spatial grid (pixel size, map size, ...).

The parameters of the output cube can still be overridden by user's MAP%LIKE and MAP% objects.

Chapter 6

Error Messages and Recovery Procedures (Out-of-Date)

Commands produce messages, either to signal their actions, or whenever they fail to execute properly to indicate the reason of the failure. The syntax of the message is the following **C-Facility, Error message text**

where C is a one letter severity code, Facility is the name of the command or of a subroutine called by the command, and “Error message text” is a short explanation.

Messages can be divided into four categories according to the severity code

- **S** (Success) or **I** (Information) messages indicate normal successful operations.
- **W** (Warning) messages indicate that the operation completed, but that the result may not be significant.
- **E** (Error) messages indicate a failure to complete the command. The result of the command is undefined, but these messages are usually signaled when checking the input parameters before executing the command. In particular, the Input and Output files are never affected by these errors.
- **F** (Fatal) messages indicate severe errors which happened while a command is executing. They may have left the input or output files in an incoherent state. These errors are typically hardware errors.

6.1 Notifying the Programmer or System Manager

Some recovery procedures ask you to submit an SPR (Software Performance Report). This means to signal the error to either the CLASS authors, the local contact person, or the system manager. Signalling the error does not mean simply just telling “Gee, I typed ABRACADABRA and the program crashed”, it implies at least giving a copy of the **CLASS.LOG** and **CLASS.MES** files, and if requested, of the data files used when the error occurred. The utilities are too complex to allow any action if these files are not given.

Please remember that if you do not signal errors, they will (at best) never be corrected. At worst, hardware errors which would have been recoverable when signalled in time may become completely unrecoverable.

6.2 Recovering Corrupted Data Files

First, let us express our most sincere hopes that you will never need to read this section... Due to hardware (or even software but this seldom happens) problems data files may become corrupted. Although this is exceptional, it can be a dramatic circumstance. The structure of the data files is fairly complex, and missing information in the index may prevent reading otherwise valid spectra in the data file. If you suspect a file may have been corrupted, first verify it by the following commands :

```

LAS> FILE IN Dubious_file_name
LAS> SET DEFAULT
LAS> FIND/ALL
LAS> FOR I 1 TO FOUND+1
LAS> GET NEXT
LAS> NEXT

```

If this series of command ends with the message 'E-GET, End of current index' everything is correct.

If not the file is corrupted and you may try to recover it partly. If the `FIND` command executes correctly, drop (by command `DROP`) from the index all the scans which cannot be read correctly (these have been lost forever). Then executes the following commands

```

LAS> FILE OUT Recovered_File_Name NEW
LAS> GET FIRST
LAS> WRITE
LAS> FOR I 1 TO FOUND
LAS> GET NEXT
LAS> WRITE
LAS> NEXT

```

If the `FIND` command does not execute correctly, try a `LIST IN` command to get the scan and version numbers. If it works or if you already have such a list, you may try to get each scan individually by specifying the scan and version numbers, and write them to another output file. In this way you might be able to recover some spectra, but it is not guaranteed.

If nothing like this works and if your file contained *vital* information you cannot reconstruct in any way, you may consider sending it to the CLASS authors which may be able to do something more. To our knowledge, such a desperate case actually happened only once in the early times of CLASS (at that time named **LAS**), to the authors who spent about 3 hours to find a way to repair the file, but managed to do it. Do not forget to supply a complete log of the errors (`CLASS.LOG` and `CLASS.MES` files).

6.3 LAS and ANALYSE Messages and Recovery Procedures

The messages not present in this list should come from the SIC monitor itself. Please refer to the SIC documentation for these.

6.3.1 A and B

E-ACCUMULATE, Coordinate systems are not compatible

LAS, SUM or ACCUMULATE commands. Two observations had different coordinate systems and could not be added.

User action : Convert them to a common coordinate system, or use the SET NOMATCH command to turn off position checking.

E-ACCUMULATE, Different calibrations

LAS, SUM or ACCUMULATE commands. Two observations were done with different major calibration parameters (Beam Efficiency and possibly Forward Efficiency) and could not be added.

User action : May be they were not on the same temperature scale. The weighting (and values) is incorrect in such a case. Modify the corresponding calibration parameter and retry. You may bypass this calibration checking by using command SET CAL OFF.

W-ACCUMULATE, Different reference channels R: <Real> T: <Real>

LAS, SUM or ACCUMULATE commands. Two spectra were added with the ALIGN mode CHANNELS, but had different reference channels, and hence possibly different velocity or frequency scales.

User action : Check if these spectra were to be added. If you want to add them and preserve a common velocity (or frequency) scale, use the ALIGN mode VELOCITY (resp. FREQUENCY).

W-ACCUMULATE, Different resolution R: <Real> T: <Real>

LAS, SUM or ACCUMULATE commands. Two spectra were added with the ALIGN mode CHANNELS, but had different resolutions and hence possibly different velocity or frequency scales.

User action : Check if these spectra were to be added. If you want to add them and preserve a common velocity (or frequency) scale, use the ALIGN mode VELOCITY (resp. FREQUENCY).

W-ACCUMULATE, Different rest frequencies R: <Real> T: <Real>

LAS, SUM or ACCUMULATE commands. Two spectra were added with the ALIGN mode CHANNELS or VELOCITY, but had different rest frequencies and hence possibly different velocity or frequency scales.

User action : Check if these spectra were to be added. If these spectra correspond to the same molecular line, use the MODIFY FREQUENCY to reset a common velocity scale and the ALIGN mode VELOCITY before adding them.

W-ACCUMULATE, Different velocities R: <Real> T: <Real>

LAS, SUM or ACCUMULATE commands. Two spectra were added with the ALIGN mode CHANNELS or FREQUENCY, but had different velocities and hence possibly different velocity or frequency scales.

User action : Check if these spectra were to be added. If these spectra correspond to the same object, use the MODIFY VELOCITY to reset a common rest frequency scale and the ALIGN mode FREQUENCY before adding them.

W-ACCUMULATE, Drift not aligned in position

LAS, SUM or ACCUMULATE commands. Two continuum drifts were added but are not coincident in position.

User action : Select POSITION alignment using command SET, and retry.

W-ACCUMULATE, Origin table overflow

LAS, SUM or ACCUMULATE commands. Too many spectra were added and the list of original scan numbers is full. Scan numbers of any other added spectrum will be lost.

User action : none. The spectrum still contains the sum the all desired spectra, only the list is wrong.

E-ACCUMULATE, Positions are not compatible

LAS, SUM or ACCUMULATE commands. Two spectra have different positions and have not been added.

User action : If you want to add them, use the SET NOMATCH command before.

E-ACCUMULATE, <String> ranges do not intersect

LAS, SUM and ACCUMULATE commands. Two spectra were to be added with the ALIGN mode specified by <String> and INTERSECT mode, but do not overlap.

User action : what do you want to add ?...

W-ACCUMULATE, Spectra not aligned in sky frequency R: <Real> T: <Real>

LAS, SUM and ACCUMULATE commands. Two spectra were added with ALIGN mode CHANNELS, but have a different sky frequency scale.

User action : use the SET ALIGN FREQUENCY if you want to preserve a common frequency scale.

E-ACCUMULATE, Too many channels requested

LAS, SUM and ACCUMULATE commands. Two spectra were added with ALIGN mode COMPOSITE, but the final spectrum requires more channels than reserved in the program.

User action : most likely you are trying to make a composite spectrum with two unrelated frequency bands, such as CO and HCN... Note also that making composite spectra is not necessary to plot a few GHz from a spectral survey.

E-ADD, Cannot add Continuum with Line data.

LAS, ACCUMULATE command: The two observations are not of the same kind. SUM command: The index contains observations of different kinds.

User action : It is time to get some rest and a cup of coffee...

W-ADD, Gives sum of spectra for EQUAL weight

LAS, ACCUMULATE command: This command gives the sum of the spectra, not the average.

User action : This behaviour is consistent with that of SUM which gives the average over the index. Using several ACCUMULATE commands, and then dividing the final result by the number of added observations yields the same result as SUM.

W-ADD, Still experimental for Continuum

LAS, ACCUMULATE and SUM commands.

User action : Poor guinea pig... Do not worry too much, it usually works fine, but we would appreciate receiving detailed comments if you find something bizarre.

E-BASE, Insufficient memory for work space

LAS, BASE command. The work space to compute the best fit polynomial could not be dynamically allocated because the program exhausted its virtual memory quota.

User action : i) clear any plot and restart. ii) run CLASS in a single process (not from a sub-process). iii) Ask your system manager to extend the virtual memory limit.

E-BASE, No line window

LAS, BASE command. No line window has been defined.

User action : define one or more windows using the SET WINDOW command.

E-BASE, No valid baseline

LAS, BASE command : the windows covers the full spectrum and leave no channels to compute the baseline

User action : define windows which do not cover the spectrum, or (if possible) compute the baseline from another backend and use the command BASE LAST to apply it to this spectrum.

E-BASE, Sinus not converged

LAS, BASE command with SINUS method. The minimization routine failed to converge to a valid solution.

User action : The solution may still be sensible, look at it. If not, retry with different guesses.

6.3.2 C**E-CBUF, Write error block <Integer>**

LAS, Input/Output routines : an error occurred during a write operation to the output file. This may be due to a large number of reasons (for example the disk may be off line, write locked or damaged) but is more or less fatal.

User action : See “Recovering Corrupted Data Files”

E-CHECK, Flag > 4

ANALYSE, LINES command : the input values contained an invalid flag.

User action : reenter valid values.

W-CHECK, Line <Integer> alone in a <String> Group

ANALYSE, LINES command. Input values were entered for dependent lines, but no lines depend on the one specified by <Integer>.

User action : although this is just a warning, it is likely that you made a typing mistake. Verify your input values and codes.

E-CHECK, No Independent <String>

ANALYSE, LINES command : input values were entered for dependent lines, but there is no independent line in VELOCITY, AREA or WIDTH (as specified by <String>).

User action : correct typing error.

E-CHECK, Several groups in <String>

ANALYSE, LINES command : input values were entered for dependent lines, but all lines must be dependent of a single one in this case. This may be due to a typing error, but also to a problem which cannot be solved by the current minimization routine.

User action : Correct typing error if any.

E-COBS, Observation not open for write nor modify

LAS, Input/Output routine : an observation is being closed after or write or modify operation, but has never been opened for such operation.

User action : Submit an SPR. The output file may have been corrupted, see “Recovering Corrupted Data Files”

W-CONVERT, Earth velocity not converted

LAS, GET command or other observation reading routine. The velocity of the source was relative to Earth, and has not been converted to the current velocity system.

User action : None, but remember the velocity is wrong...

W-CONVERT, Velocity type was unknown, Set to <String>

LAS, GET command or other observation reading routine. The velocity type was undefined, and has been (arbitrarily) declared as <String> (LSR, Helio, etc...), but no velocity conversion was done.

W-CONVER, label too long, truncated

LAS, plotting routines. A label was too long to be drawn.

User action : None. Submit an SPR if you wish, with the label of course.

F-COX, Output file not opened

LAS, Input/Output routine : an operation was requested on the output file, but no such file has been opened.

User action : open the output file, and resubmit the command.

F-COX, Write error block <Integer>

LAS, Input/Output routines : an error occurred during a write operation to the output file. This may be due to a large number of reasons (for example the disk may be off line, write locked or damaged) but is more or less fatal.

User action : Notify your system manager. The output file may have been corrupted, see "Recovering Corrupted Data Files"

E-CUBE, Cannot create output image

ANALYSE, CUBE command. The output image could not be created. This message is followed by a message 'E-GDF_CRIMAG,' which gives the reason of the failure. The most likely reason is an exceeded quota (either disk or virtual memory)

User action : if this is due to a disk quota, delete unwanted files and retry. If this is due to a virtual memory quota, clear any plot, run the program without parallel sub-processes, and if none of these solution works, ask your system manager.

E-CUBE, Cannot write output image header

ANALYSE, CUBE command. The output image header could not be written. This error is due to an hardware error on the disk.

User action : Notify the system manager, and retry again later.

I-CUBE, Check tolerance (SET MATCH) please

ANALYSE, CUBE command. The output cube is too large, possibly because of roundoff errors in the offsets.

User action : increase the SET MATCH to overcome roundoff errors.

E-CUBE, Continuum data not supported

ANALYSE, CUBE Command. Spectral line data is required to make a data cube. Use command STRIP to build a continuum map from a set of scans.

E-CUBE, Cube too large, <Integer> by <Integer>

ANALYSE, CUBE command. The output cube is too large, most likely because of roundoff errors in the offsets.

User action : see "I-CUBE, Check tolerance (SET MATCH) please"

W-CUBE, Incoherent axis scale for scan <Integer>

ANALYSE, CUBE command. One of the spectra in the index has an axis scale which does not match the cube definition. The spectrum has been written to the cube nevertheless, and the cube command proceeds.

User action : May be this spectrum should not be placed in the cube, so drop it from the current index and rebuild the cube. If spectra have been obtained under slightly different conditions (for example with different sidebands) you must bring them on a common axis scale (use RESAMPLE) before combining them in a cube.

E-CUBE, Incoherent number of channels for scan <Integer>

ANALYSE, CUBE command. One of the spectra has a number of channels different from the cube definition. The spectrum is not written to the cube, and the cube command aborts.

User action : drop this spectrum from the current index and restart command.

E-CUBE, Incoherent offset type for scan <Integer>

ANALYSE, CUBE command. The coordinate system of the scan differs from the one of the cube. The scan is not written, and command CUBE aborts.

User action : drop the scan from the index, and restart command.

E-CUBE, Index is empty

ANALYSE, CUBE command. A cube is being build from nothing...

User action : define your current index before by using command FIND.

E-CUBE, Missing file name

ANALYSE, CUBE command. The output cube name has not been specified

User action : specify file name

E-CUBE, No input file connected

ANALYSE, CUBE command. No input file is opened.

User action : open input file and define the current index before using command CUBE.

6.3.3 D and E

W-DEVICE, No device active

LAS, DEVICE command. No graphic device is currently connected.

User action : it is nevertheless possible to produce plots and hardcopies without a graphic device. A graphic device can be connected later at any time to visualize the plots.

W-DISPLAY, No Fit for scan <Integer>

ANALYSE, DISPLAY command. There is no fit (of the current method) for this scan.

E-DIVIDE, Spectra do not have the same velocity scale

ANALYSE, DIVIDE command. The R and T spectra must have the same number of channels and a common velocity scale to divide T by R.

User action : Use command RESAMPLE to rescale both spectra on the same grid.

E-DIVIDE, Spectra have different number of channels

ANALYSE, DIVIDE command. The R and T spectra must have the same number of channels and a common velocity scale to divide T by R.

User action : Use command RESAMPLE to rescale both spectra on the same grid.

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E-DRAW, Invalid Centering

ANALYSE, DRAW command with argument TEXT. The centering code for the character string is invalid.

User action : valid code range is 1-9.

E-DRAW, No cursor available

ANALYSE, DRAW command. The DRAW command is used without a completely explicit form, but no cursor is available to supply the missing parameters, either because no graphic device is connected, or because the current graphic device has no cursor.

User action : supply all missing parameters to the command, or connect a graphic device with cursor.

E-DRAW FILL, Channel is not blanked

ANALYSE, DRAW command with argument FILL. The channel to be interpolated already contains a valid value. This may be because you typed F by mistake in the cursor mode.

User action : If you really want to interpolate this channel, kill it before by using command DRAW KILL.

E-DRAW FILL, Channel outside spectrum

ANALYSE, DRAW command with argument FILL. The channel to be interpolated is outside the spectrum boundaries. This may be because you typed F by mistake in the cursor mode, or because the cursor lies outside the spectrum boundaries.

User action : Move the cursor to the channel to be interpolated before typing the code F.

E-DRAW KILL, Channel outside spectrum

ANALYSE, DRAW command with argument KILL. The channel does not exist in this spectrum, probably because the graphic cursor does not point where you would like.

User action : move graphic cursor towards the channel to kill.

E-DROP, Current index is empty

LAS, DROP command. The current index is empty, so that no scan could be dropped from it...

I-DROP, <Integer>;<Integer> not in current index

LAS, DROP command. The scan to be dropped is not in the current index. This is most likely due to a typing error.

E-DROP, End of current index encountered

LAS, DROP command with argument NEXT. The end of the index has been reached.

Error encoding <Real>

Sexagesimal label routines. The value to be encoded in sexagesimal form is out of valid range.

User action : Submit an SPR.

I-EIX, New data present

LAS, NEW_DATA or FIND command with argument NEW. New data has been found in the input file, execution resumes.

W-EIX, No input file opened

LAS, NEW_DATA or FIND command with argument NEW. No new data can be found in nothing...

F-EIX, Read error file <String>

LAS, NEW_DATA or FIND command with argument NEW. A read error occurred while reading the header block of the input file when looking for new data.

User action : Retry, this is usually due to an interlock problem. If the error persists, check that no more than 2 processes are accessing the specified file.

I-EIX, Switching to <String> Mode

LAS, NEW_DATA command. The new data found is of a different type than the current one. Switching to the new type occurred.

User action : Remember not all actions are possible on every type of observations.

I-EIX, Waiting loop aborted by <^C>

LAS, NEW_DATA or FIND command with argument NEW. The wait has been interrupted by user action. No new data was found.

6.3.4 F**E-FILE, IN OUT or BOTH please**

LAS, FILE command. The first argument is incorrect (typing error).

E-FILE, No default is provided for the file name

LAS, FILE command. The second argument (file name) is missing.

I-FIND, <Integer> observations found

LAS, FIND command, information message.

E-FIND, Nothing found

LAS, FIND command, information message. Variable FOUND is reset to 0.

User action : if you believe something should have been found, check the various selection criteria. One is probably different from what you had in mind.

I-FIND, <Integer> observations in index

LAS, FIND command with argument APPEND, information message. The index has been appended and compressed to avoid duplicate entries to a given scan.

W-FITCONT, Solution not converged

W-FITGAUSS, Solution not converged

W-FITNH3, Solution not converged

W-FITSHELL, Solution not converged

ANALYSE, GAUSS command. The minimization failed to converge to a valid solution.

User action : Look at the results using command FIT. If they seem good enough, use command ITERATE until convergence is reached. If the warning persists, may be the problem is badly defined and the solution unreliable.

E-FITNH3, Unit X must be Velocity

LAS, GAUSS command for method NH3. The X unit must be velocity to fit NH₃ hyperfine structure.

User action : use command SET UNIT X V, reset new guesses using command LINES and retry.

E-FITSHELL, No baseline removed

ANALYSE, GAUSS command, SHELL method. A base line must have been removed before fitting.

User action : use the BASE command to remove a baseline, and retry.

E-FITSHELL, Unit X must be Frequency

ANALYSE, GAUSS command, SHELL method. “Circumstellar shells” like profile fitting is only possible in Frequency units.

User action : use command SET UNIT X F, check the initial guesses and retry.

F-FIX, Current index is full

LAS, FIND command, usually with APPEND argument. Too many spectra match the current selection criteria, and the index is too large. Some spectra have been omitted from the index.

User action : Restrict the search by adding more severe selection criteria. Note in any case that you will have troubles processing the connected input file because it contains too many spectra. It would be wise to split this file in smaller ones, according to selected criteria.

E-FIX, More than <Integer> observations found

LAS, GET or other commands involving index finding operations, such as DROP. There are too many scans matching the requested criteria. Most likely, this error is due to an incoherent input file which contains twice the same scan (number AND version).

User action : It is possible to get rid of the duplicate scans by the following recipe. i) define a new output file to receive the valid spectra. ii) use a FIND/ALL without any selection criterium. iii) use the GET NEXT command to retrieve scans. iv) use the WRITE command for all scans but the duplicate scans that you should either skip or write under a new scan number (WRITE Number command). The new output file should be correct. If not see “Recovering Corrupted Data Files”.

E-FIX, Read error

LAS, FIND or other commands involving index finding operations. This may be due to a lack of input file (not all commands are explicitly protected against this specific mistake), but also to hardware problems.

User action : after checking for the input file, retry the operation. If the error persists, submit an SPR, and see “Recovering Corrupted Data Files”

W-FOLD, Cannot fold a single phased spectrum

LAS, FOLD command. The current spectrum was not observed in frequency switching mode, so that it cannot be folded.

E-FOLD, No channels left in spectrum

LAS, FOLD command. The align mode is INTERSECT, and the frequency switch is so large that no channel overlap from one phase to the others.

User action : Set the align mode to COMPOSITE, and redo the command.

E-FSHELL, Wrong Arguments : <Real>

ANALYSE, GAUSS command with method SHELL. The minimization routines went into a forbidden region for the parameters. The minimization aborts.

User action : retry the fit with a different choice of input parameters.

6.3.5 G through I

E-GAUSS, No baseline removed

ANALYSE, GAUSS command with method GAUSS. Minimization requires that a baseline be removed before.

User action : remove a baseline with command BASE and retry the fit.

E-GET, End of Current Index Encountered

LAS, GET command with argument NEXT. There are no more scans in the index.

I-GET, Entry <Integer> Found <Integer>;<Integer>

LAS, GET command, information message.

E-GET, Index is empty

LAS, GET command with argument FIRST. There is no first observation.

E-GET, No input file connected

LAS, GET command. No input file is opened, so that the requested scan cannot be read...

E-GET, Observation <Integer>;<Integer> not Found

LAS, GET command. The specified scan was not found in the input file. The version number (second <Integer>) is output only if it was specified in the command.

User action : check for typing errors.

I-GREG, Creating Formatted <String>

LAS, GREG command. This information message indicates that the output file <String> is formatted.

I-GREG, Creating Table <String>

LAS, GREG command. This information message indicates that the output file <String> is a GILDAS Table. Note that this is the default.

E-GREG, Cannot open <String>

LAS, GREG command. The output file (formatted or table) could not be created. This message is followed by more precise information about the failure. Most likely failures are: invalid name, exceeded quota, privilege violation.

User action : it depends on the precise reason. Purge and delete any unwanted file if a quota problem is the basic cause and retry.

E-HARD, Conflicting options

LAS, HARDCOPY command. Two conflicting options (e.g. /PORTRAIT and /LANDSCAPE) were given

User action : remove the unwanted option

E-HARD, Invalid plot mode <String>

LAS, HARDCOPY command. The scaling mode is invalid. Refer to the HELP HARDCOPY for valid scaling modes.

E-HARD, Non standard plot page, Specify option please

LAS, HARDCOPY command. The plot page size does not match the default values, so that the orientation for hardcopy must be specified (/LANDSCAPE or /PORTRAIT).

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S-HARD, <String>/<String> created

LAS, HARDCOPY command with argument, information message. The first string indicate the vector file name, and the second the orientation.

S-HARD, Plot request successfully enqueued on GAG_PLOTTER

LAS, HARDCOPY command with option /PLOT.

I-INIT, <String> initialized

LAS, FILE OUT command with third argument NEW specified, information message. A new empty output file has been initialized.

E-INIT, Open error file <String>

LAS, FILE OUT command with third argument NEW specified. The output file could not be created. This message is followed by more explanations about the precise reason (exceeded quota, privilege violation, invalid file name, etc...)

User action : respond according to the precise reason.

E-INIT, Write error file <String>

LAS, FILE OUT command with third argument NEW specified, information message. The output file was created, but could not be initialized properly. This is most likely due to a disk hardware error.

User action : Notify the system manager and retry.

I-INPUT, <String> successfully opened

LAS, FILE IN command. Information message : the specified input file has been opened.

I-INPUT, <String> is reopened

LAS, FILE IN command. This message appears whenever a new input file could not be opened, to indicate which file is still currently opened.

I-INPUT, No input file opened

LAS, FILE IN command. This message appears whenever a new input file could not be opened, and no input file was previously opened.

F-INPUT, Non standard file <String>

LAS, FILE IN command. The specified file could be opened, but is not a valid CLASS file.

User action : Check the file name.

F-INPUT, Open error file <String>

LAS, FILE IN command. The specified input file could not be opened. The message is followed by more details about the reason of the open failure.

User action : verify the file name you typed, and retry.

F-INPUT, Read error file <String>

LAS, FILE IN command. The specified file could be opened, but the first block could not be read. This is most likely because the file is not a standard CLASS file, but anything else. If you are sure that the file is a valid CLASS file, this indicates a hardware problem.

User action : Check the file name or notify the system manager accordingly.

E-ITERATE, Bad input parameters

ANALYSE, ITERATE command. The input parameters are non valid. This may happen because you have changed the X unit or the R spectrum till the last fit.

User action : verify X unit and change the input parameters, or use the GAUSS command.

6.3.6 K and L

E-KEEP, Input file must equal output file

ANALYSE, KEEP command. The KEEP command does an update of the spectrum, and the input and output files must be identical for this.

User action : open the input file as the output file and retry, or use the WRITE command.

I-KEEP, Observation <Integer>;<Integer> successfully updated

ANALYSE, KEEP command, information message.

E-KSHELL, Wrong Arguments : <Real>

ANALYSE, GAUSS or FIT commands with method SHELL. The minimization algorithm produced an invalid solution.

User action : This also means that the fit is not converged. Restart it with different input parameters.

E-LAS, <String> Not yet implemented

LAS or ANALYSE languages, You are trying to use an undocumented, unimplemented command.

User action : Don't

W-LAS, Save file could not be opened

LAS, SAVE command. The output file could not be opened, may be because of an exceeded disk quota, or invalid file name.

User action : check the disk quota (and space) and the file name and retry.

E-LINES, Error opening guess file <String>

ANALYSE, LINES command. The input file for guesses could not be opened. This message is followed by more details about the precise reason of the open failure. React accordingly.

E-LINES, Error reading guesses from <String>

ANALYSE, LINES command. The input file specified for guesses contains invalid data.

User action : check the input file format.

E-LINES, Invalid number of lines

ANALYSE, LINES command. The user specified either a negative number of lines or too many lines.

E-LINES, Not implemented for Continuum method.

ANALYSE, LINES command has no action for Continuum method.

W-LINES, Null area found, use manual mode

ANALYSE, LINES command. The area found in cursor mode is zero, may be because you forgot to move cursor between the two edges...

User action : Try to give slightly different boundaries with the cursor, or use the manual mode (/NOCURS) as suggested.

W-LINES, Use of cursor with dependant or fixed lines not supported

ANALYSE, LINES command. The user is using the cursor to specify input values, but the flags indicate that some parameters are fixed or dependent.

User action : It is not forbidden to use the cursor in such a case, but the user should realized that the guesses will always be those found by the cursor routine, superseding any previous value (unless a slash / is typed in the cursor routine).

I-LISTE, Input file is empty
I-LISTE, Input file contains
I-LISTE, Output file is empty
I-LISTE, Output file contains
I-LISTE, Current index is empty
I-LISTE, Current index :
LAS, LIST command, information messages

I-LISTE, List on file <String>
LAS, LIST command, information message specifying to which file the listing has been sent.

6.3.7 M

E-MAP, Continuum data not supported.
ANALYSE, MAP command. The current index contains continuum drifts, instead of spectra.
MAP only works on spectral line data.

E-MAP, Incoherent offset type for scan <Integer>
ANALYSE, MAP command. The current index contains offsets in different coordinate systems.
User action : drop the faulty spectrum from the index.

E-MAP, Index is empty
ANALYSE, MAP command. No map can be plotted.
User action : Define the current index using the FIND command and retry.

E-MAP, Map too large, <Integer> by <Integer>
I-MAP, Check tolerance (SET MATCH) please
ANALYSE, MAP command. The number of cells in the map defined by the index is too large, so that the spectra would be too small. This may be due to rounding errors in the offsets which lead to an anomalously small cell size.
User action : increase the tolerance in SET MATCH by a factor 2. If the error persists, give explicitly the cell size (/CELL option) If this does not help either, verify that the index does correspond to a single source.

E-MAP, Mode X and Y must be fixed
ANALYSE, MAP command. The X and/or Y axis has an automatic scaling enable, and must have a fixed scale.
User action : Specify a fixed scale for all spectra using the SET MODE command, and retry the MAP command.

E-MAP, No input file connected
ANALYSE, MAP command. No input file is opened.
User action : Open the input file, define the current index using the FIND command and retry the MAP command.

E-METHOD, Cannot open HFS description file.
E-METHOD, Error reading HFS description file.
ANALYSE, METHOD command with argument HFS. The Hyperfine structure of the line to be fitted could not be read from the specified file.
User action : Check the file name or content for proper format. See HELP METHOD.

E-METHOD, Too many HFS components

ANALYSE, METHOD command with argument HFS. The hyperfine structure specified has too many components.

User action : Relinking the program is required to increase this parameter. Contact the authors and supply the number of components required. You may solve adequately your problem by suppressing from the description the weakest components if they are negligible.

E-MOBS, Observation to be modified was not found

LAS, Input/Output routines, UPDATE or KEEP commands. The user attempted to modify an unexistent observation.

E-MOBS, Non-standard obs. block <Integer>

LAS, Input/Output routines, UPDATE or KEEP commands. The input/output file contains an invalid data block because it has been corrupted.

User action : see “Recovering Corrupted Data Files”, and notify your system manager because this is usually due to hardware errors.

I-MODIFY, Beam efficiency set to <Real>

ANALYSE, MODIFY command. The beam efficiency value was previously undefined and has been set to the specified value. No scaling occurred.

E-MODIFY, Invalid beam efficiency <Real>

ANALYSE, MODIFY command. The beam efficiency value must be between 0 and the forward efficiency (less than 1).

E-MODIFY, MODIFY POSITION not supported for this type of projection ANALYSE, MODIFY command. Offsets relative to the new central position cannot be computed in the present coordinate or projection system

User action : Submit an SPR, specifying the projection used. We will try to implement it properly in future releases.

I-MODIFY, Offsets set to <String>

ANALYSE, MODIFY OFFSETS command. Information message.

I-MODIFY, Reference channel set to <Real>

ANALYSE, MODIFY RECENTER command, information message.

I-MODIFY, Image frequency set to <Real>

ANALYSE, MODIFY IMAGE command, information message.

W-MODIFY, Unknown projection type, Radio projection assumed

ANALYSE, MODIFY command. Offsets relative to the new central position were in a unknown projection system.

F-MOX, Output file not opened

LAS, Input/Output routines. A WRITE operation was attempted before any output file was opened.

User action : open output file and retry the aborted command.

F-MOX, Read error block <Integer>

LAS, Input/Output routines. A WRITE operation failed because the output file index could not be read correctly.

User action : see “Recovering Corrupted Data Files” and notify your system manager.

F-MOX, Write error block <Integer>

LAS, Input/Output routines. A WRITE operation failed because the output file index could not be written correctly.

User action : see “Recovering Corrupted Data Files” and notify your system manager.

E-MOX, Wrong index address <Integer>

LAS, Input/Output routines. A WRITE operation failed because the index address is incorrect. This may be due to update a spectrum which does not exist in the output file.

User action : if the error was caused by an UPDATE or KEEP command, try a WRITE command instead ; else, or if the error persists, submit an SPR.

6.3.8 N-Q**F-NOISE, No spectrum in memory**

LAS, NOISE command. The command was specified without arguments, but there is no spectrum in the R memory to estimate a noise level.

User action : Specify a noise level, or get a spectrum in R.

I-OUTPUT, <String> is reopened

LAS, FILE OUT command, information message.

I-OUTPUT, <String> successfully opened

LAS, FILE OUT command, information message.

W-OUTPUT, No output file opened

LAS, FILE OUT command. The specified file could not be opened, or is not a valid CLASS file, but no previous output file has been reopened.

F-OUTPUT, Non standard file <String>

LAS, FILE OUT command. The specified file could be opened, but is not a CLASS data file.

User action : probably the file name has been mistyped.

E-OUTPUT, Old format not supported

LAS, FILE OUT command. The specified file has an old data format, and cannot be used for output.

User action : this file can be used for input. You may create a copy of it in new format by reading and writing to a new file all observations contained in it.

F-OUTPUT, Open error file <String>

LAS, FILE OUT command. The specified output file could not be opened. The message if followed by more details about the specific reason for the open failure. The most likely reasons are i) a non existing file, ii) a privilege violation (the user has not write access to the output file), or iii) the file may also be locked by another user.

User action : If you want to create a new output file, specify the 3rd argument NEW to the FILE OUT command.

F-OUTPUT, Read error file <String>

LAS, FILE OUT command. The specified file could be opened, but most likely is not a CLASS data file.

User action : verify the file name, which may have been mistyped. If it is correct, notify your system manager because the error is due to a hardware problem.

E-PEN, Number outside boundaries 0 - 15

E-PEN, Default pen not changed

LAS, PENCIL command. A bad pen number was specified, the pen number is left unchanged.

W-PEN, Colour outside boundaries 0 - <Integer>

W-PEN, Default colour 0 used

LAS, PENCIL command. A bad colour index has been specified, the colour index is reset to the default value 0.

W-PEN, Dashed pattern outside boundaries 1 - 7

W-PEN, Default dashed pattern 1 used

LAS, PENCIL command. A bad dashed pattern has been specified, the dash pattern is reset to the default value 1 (continuous line).

W-POLYNO, Baseline extrapolation is hazardous

LAS, BASE command. Some of the line windows touch the spectrum edges, so that the baseline must be extrapolated in this range. Extrapolation is made by assuming a constant value in the range, and not by using the polynom because the solution is unstable.

User action : If possible, try to avoid such situations by having a few channels free of lines at the spectrum edges. Note that the extrapolation is most likely incorrect.

W-POLYNO, Degree <Integer> would be even better

LAS, BASE command. The specified degree would have given as good a fit to the baseline. It is hence possible that the current degree is too high and creates spurious oscillations.

E-POLYNO, NAG Error in <String>, ifail = <Integer>

LAS, BASE command. The minimization failed or the minimum is ill-defined.

User action : try to change the degree of the baseline, or the definition of the line windows to obtain a better solution.

W-PRINT, At entry <Integer> Scan <Integer>;<Integer>

ANALYSE, PRINT command. The information to be listed is missing or incomplete for the specified scan. This message is usually preceded by "W-RSEC, Absent section <Integer>"

E-PRINT, Cannot print <String>

ANALYSE, PRINT command. The specified keyword is not (yet) recognized.

E-PRINT, No input file connected

ANALYSE, PRINT command. There is nothing to print...

E-PRINT, Option /TABLE invalid for FIT

ANALYSE, PRINT command. FIT results cannot be written to a GILDAS table, but only to a formatted file.

E-PRINT, No channel list

ANALYSE, PRINT CHANNEL command. The channel list is missing or incorrectly given.

E-PRINT, Syntax error in list : <String>

E-PRINT, Invalid list : <Integer> TO <Integer> BY <Integer>

E-PRINT, Incomplete list : <String>

E-PRINT, Empty list

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ANALYSE, PRINT command (possibly with the CHANNEL argument). The list is incorrect in some way.

User action : Correct the faulty list and resubmit the command.

W-PRINT, Too many channels, list truncated

ANALYSE, PRINT CHANNEL command. The channel list is too long and has been truncated.

User action : check the output file to see which channels are missing and use another PRINT command to list the missing channels.

E-PRINT, Too many arguments in list

ANALYSE, PRINT command for velocity ranges. There are too many velocity ranges specified.

E-PRINT, Unable to open file <String>

ANALYSE, PRINT command with /OUTPUT option. The output file could not be created, possibly because of open file quota, disk quota, privilege violation to the directory, or simply invalid file name.

6.3.9 R

E-RBUF, Read error block <Integer>

LAS, Input/Output routines. The specified block could not be read. This is most likely due to a hardware error.

User action : see “Recovering Corrupted Data Files”. Notify your system manager.

W-RDATA, Too many channels, truncated

LAS, Input routines. The observation contains too many data points (more than 2048). Only 2048 channels were read.

W-REDUCE, Only valid for skydips

ANALYSE, REDUCE command. This command is only effective on skydips. Nothing happened.

E-RESAMPLE, Invalid unit type <String>

ANALYSE, RESAMPLE command. The resampling unit is unknown, it should be Velocity or Frequency.

E-RESAMPLE, New spectrum does not intersect the original one

ANALYSE, RESAMPLE command. The resampling formula creates a spectrum which does not intersect with the current one.

User action : use the HEADER command to see the current velocity or frequency scale for the current spectrum, and provide RESAMPLE arguments which are consistent with this scale.

E-RESAMPLE, Too many output channels, maximum is <Integer>

ANALYSE, RESAMPLE command. The parameters imply too many channels.

User action : decrease the resolution.

F-RIX, Input file not opened

LAS, Index routine. There is no input file connected.

F-RIX, Read error block <Integer>

LAS, Index routine. Unless it is preceded by the “E-RIX, Wrong index address” message, this error indicates a hardware problem.

User action : notify your system manager.

E-RIX, Wrong index address <Integer>

LAS, Index routine. The specified address does not exist. This error is usually due to an attempt to use a command such as GET or GET NEXT after an input file change.

User action : For these commands, use a FIND command before, or specify an observation number.

E-ROBS, Non-existing index entry <Integer>

LAS, Input/Output routine. The specified entry does not exist in the input file. This error is usually due to an attempt to use a command such as GET or GET NEXT after an input file change.

User action : For these commands, use a FIND command before, or specify an observation number.

E-ROBS, Non-standard obs. block <Integer>

LAS, Input/Output routine. The specified block does not have the valid CLASS data format.

User action : Submit an SPR, and see “Recovering Corrupted Data Files”

E-ROBS, Read error in index block

LAS, Input/Output routine. The main index block could not be read.

User action : Retry later. Submit an SPR and see “Recovering Corrupted Data Files” if the error persists.

F-ROX, Output file not opened

LAS, Index routine. There is no output file connected.

E-ROX, Wrong index address <Integer>

LAS, Index routine. The specified address does not exist in the output file.

User action : Submit an SPR.

F-ROX, Read error block <Integer>

LAS, Index routine. The specified block could not be read in the output file.

User action : notify the system manager. The file may have been corrupted, see “Recovering Corrupted Data Files”.

W-RSEC, Absent section <Integer>

LAS, Input/Output routines. The specified section does not exist in the current scan.

E-RUNLAS, No spectrum in memory

LAS, main program. The current command requires a scan, but no one has been read yet.

6.3.10 S

E-SET BOX_LOCATION, Four arguments required

LAS, SET BOX command, information message, see help.

E-SET MODE, Invalid axis type <String>

LAS, SET MODE command. Only two axis are recognised by this command : X and Y.

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E-SET PLOT_PAGE, Two arguments required

LAS, SET PLOT command, information message, see help.

I-SET, Clearing the plot and resetting BOX_LOCATION

LAS, SET DEFAULT command, information message.

W-SET, Invalid <String> <String>

LAS, SET command, information message, see help.

I-SET, Default file extension set to <String>

LAS, SET command, information message, see help.

I-SET, Message display level set to <Integer>

LAS, SET MESSAGE, information message. Note that the message level has effect upon the number of messages output by CLASS. The default level is 4. Higher values may suppress important messages. Lower values can be used.

W-SKYDIP, Solution not converged

ANALYSE, REDUCE command. The minimization failed to converge.

User action : None, but the results may be unreliable.

E-SKYDIP, Stupid calibration No oxygen in atmosphere

E-SKYDIP, Stupid calibration No water in atmosphere

E-SKYDIP, Stupid calibration Zero atmospheric opacity

ANALYSE, REDUCE command. The minimization converged to a stupid solution.

User action : The calibration parameters of the skydip are probably incorrect. Discard the result.

E-SMOOTH, Box width out of range

ANALYSE, SMOOTH BOX command. The Box width is less than 2 or too large.

W-SMOOTH, Cross-validation not converged

ANALYSE, SMOOTH AUTO command. The cross-validation did not converge, no smoothing has been done.

User action : None. There is no way to force the cross validation to converge.

W-SMOOTH, Error in AUTO smoothing

ANALYSE, SMOOTH AUTO command. An error in the cross-validation algorithm happened. No smoothing has been done.

User action : Submit an SPR, supplying the data on which AUTO smoothing was tried.

E-SMOOTH, Number of points out of range

ANALYSE, SMOOTH command with argument NOISE.

User action : Decrease the number of channels

E-SMOOTH, Too few channels

ANALYSE, SMOOTH command. There are too few channels to make the smoothing.

E-SPECTRUM, No spectrum in memory.

LAS, SPECTRUM or PLOT commands. Not spectrum has been read yet.

E-STAMP, Mode X and Y must be fixed

ANALYSE, STAMP command. All spectra must have the same scale. Use the SET MODE command to do so.

W-STAMP, More spectra in index than plotted.

ANALYSE, STAMP command. All spectra in index could not be plotted.

User action : Change the number of spectra along each direction, or drop observations from the index.

E-STAMP, No input file connected

ANALYSE, STAMP command. No input file is currently opened.

User action : Open the desired input file, define an index using command FIND and retry the command.

E-STRIP, Cannot create output image

E-STRIP, Cannot write output image header

ANALYSE, STRIP command. The output file could not be created.

User action : this is usually a problem of file name, privilege or disk quota. Check these parameters.

E-STRIP, Continuum data not supported

ANALYSE, STRIP command with LINE type. The index contains data of continuum type.

User action : drop the invalid observation from the index.

E-STRIP, Index does not define a strip

ANALYSE, STRIP command. The index contains spectra which cannot be aligned along one of the two main directions.

User action : Check the index by command LIST, and build one which only contains offsets changing in one direction. If you want to do a strip in a diagonal direction, the only possibility is to modify the offset so that they describe a linear strip. Do not forget the changes if you do so...

E-STRIP, Index does not define a continuum map

ANALYSE, STRIP command in CONTINUUM type. The index contains continuum drift which cannot be aligned.

User action : Check the index by command LIST, and build one which only contains offsets changing in one direction.

E-STRIP, Too few points in position

ANALYSE, STRIP command. The index contains less than two spectra.

User action : Most likely your index does not contain what you believe. Check the index by command LIST, and build the one you want.

E-STRIP, Too few points continuum drifts

ANALYSE, STRIP command in CONTINUUM type. The index contains less than two drifts.

User action : Most likely your index does not contain what you believe. Check the index by command LIST, and build the one you want.

W-SUM, Added folded to unfolded spectra.

LAS, SUM command. The index contains observations made in frequency switching mode which have not been folded, and some which have been folded (or were made in other

switching mode).

User action : Check your index, drop the incoherent spectra.

I-SUM, Entry <Integer> found <Integer> ; <Integer>
LAS, SUM command, information message.

E-SUM, Index is empty
LAS, SUM command.

User action : Build the index using command SUM, and try again.

E-SUM, No input file connected
LAS, SUM command. There is no input file.

User action : define an input file using command FILE, build the index using command FIND, and try again.

E-SUM, Sum interrupted by <^C>

LAS, SUM command. The sum was interrupted by the user by pressing <^C>. In general, the R spectrum contains nothing sensible in this case.

User action : None. Do not write the spectrum.

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W-TAG, Observation <Integer> not found

LAS, TAG command. The observation to be tagged does not exist, or is not of the current type.

E-TAG, Quality out of range

LAS, TAG command. Quality must be in the range 0-9 (0 Unknown, 1 to 8 from Excellent to Very bad, 9 reserved for deleted observations).

E-UPDATE, Can only update last versions

LAS, UPDATE command. Only last versions can be updated, the command had no effect.

User action : Use command WRITE instead of command UPDATE, but note that the new spectrum will become the last version in this case.

E-UPDATE, Input file must equal Output file

LAS, UPDATE command. The command had no effect.

User action : open the input as the output file too, and retry the command.

E-WBUF, Read error block <Integer>

LAS, Input/Output routines. A READ operation failed. The output file may be corrupted.

User action : notify your system manager. If the output file is corrupted, try to recover as many spectra as possible (cf “Recovering Corrupted Data Files”).

E-WBUF, Write error block <Integer>

LAS, Input/Output routines. A WRITE operation failed. This usually corresponds to an exceeded disk quota. This error may also be due to a write-lock error on the output device. In these cases, the WRITE operation can be done later. The problem can also be more serious and indicate a corrupted output file.

User action : check disk quota. Notify your system manager. If the output file is corrupted, try to recover as many spectra as possible (see “Recovering Corrupted Data Files”).

E-WDATA, Observation not open for write nor modify

LAS, Input/Output routines. An UPDATE or WRITE operation failed because the observation was not opened for write.

User action : This indicates an internal logic error in CLASS and should never occur. Submit an SPR.

E-WDATA, Insufficient space available for data section

LAS, Input/Output routines. An UPDATE or WRITE operation failed because the observation length is declared too short.

User action : This indicates an internal logic error in CLASS and should never occur. Submit an SPR.

F-WOBS, No output file opened

LAS, Input/Output routines. A WRITE operation failed because there is no output file.

User action : Open an output file.

F-WOX, Output file index is full

LAS, Index output routines. A WRITE operation failed because there are too many spectra in the output file. Nothing has been written.

User action : There are two possibilities i) open a new output file and write the spectrum. ii) you may consider compressing the output file by keeping only the last versions of the spectra, and then open the compressed output file and write the spectrum.

F-WOX, Read error block <Integer>

LAS, Index routines. A WRITE operation failed because the index could not be read correctly. This probably indicates a hardware problem.

User action : notify your system manager.

F-WOX, Write error block <Integer>

LAS, Index routines. A WRITE operation failed because the index block could not be written correctly. This probably indicates a hardware problem.

User action : notify your system manager.

I-WRITE, Observation <Integer>;<Integer> successfully <String>

LAS, WRITE or UPDATE commands, information message. <String> indicates whether the observations was updated or written.

E-WSEC, Observation not open for write or modify

LAS, Input/Output routines. A WRITE operation failed because the observation is defined as readonly.

User action : This indicates an internal logic error in CLASS. Submit an SPR.

F-WSEC, Too many sections

LAS, Input/Output routines. A WRITE operation failed because there are too many sections in the current spectrum to be written in the current file. This should not happen in the basic CLASS, but may occur to people using extended CLASS capabilities with user-defined sections.

User action : Submit an SPR, specifying the number of user-defined sections.

F-WSEC, Section <Integer> already written

LAS, Input/Output routines. A WRITE operation failed because the specified section already

exists. This indicates an internal logic error.

User action : Submit an SPR.

F-WSEC, Insufficient room available for section <String>

F-WSEC, Absent section <String>

LAS, Input/Output routines. An UPDATE operation failed because the specified section is longer in the R spectrum than in the output file.

User action : use the WRITE command instead (immediately to avoid leaving the observation half modified in the output file).

E-ZOOM, No cursor available

LAS, ZOOM command without arguments. No cursor is available to define the zooming window.

User action : supply the zooming window explicitly.

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