Chapter 1

Data Reduction I - CHEF/TOOLBOX

1.1 CHEF

Original version by S. Liechti, 1993. Additional text by SMTO staff.

1.1.1 Introduction

CHEF is a calibration and reduction program written for the HHT by Stella Liechti; it is based on the EFF program used at Effelsberg.

CHEF is a program to reduce the raw data obtained with the Heinrich Hertz submillimeter telescope and convert them into **CLASS** format when possible.

CHEF is in fact a superset of **CLASS** so that once entered in **CHEF** all the **CLASS** commands are also available (and some are usually used for example to define the graphic device, to open the **CLASS** output file, and to plot and write the calibrated data). This means also that **CHEF** is a **SIC** based program: commands are entered following the **SIC** syntax, loop can be used, etc. As a consequence, **CHEF** can be used instead of **CLASS** for reducing the data already converted in **CLASS** format. It is then recommended to the reader not familiar with **SIC** and **CLASS** to consult first the corresponding manuals.

CHEF is simple to use to convert data taken with some "standard" procedures (see section) but can also be used with data taken in non-standard way.

CHEF can also be used as the on-line display program in connection with the observer input command program.

1.1.2 Cookbook

Here is an example of a **CHEF** session to convert 2 consecutive raster map scans with calibration scan before each, into **CLASS** format and plot the obtained **CLASS** spectra.

```
DEVICE X IMAGE                  !1
FILE OUT TEST.SMT NEW           !2
```

```
DIRECTORY [SMT.DATA]           !3
SUPPLY CAL COLD                !4
SUPPLY AMBIENT 280 670         !5
SUPPLY CHOPPER 290 80/FE 1     !6
SUPPLY EFFICIENCY 1.0 1.0/FE 1 !7
SUPPLY GAIN 1.0/FE 1           !8
SUPPLY LINE 12CO(3-2)/FE 1     !9
CALIBRATE 5519                 !10
PROCEDURE PRASTER              !11
DORED N                        !12
CALIBRATE N COLD               !13
DORED N                        !14
! Class procedure to display the resulting spectra
FILE IN TEST.SMT
FIND/ALL
FOR I 1 TO FOUND
GET NEXT
PLOT
NEXT
!
EXIT
```

- 1. Define the graphic output terminal for plotting spectra. (**CLASS** command).
- 2. Define the output Class-like file where the spectra are to be written. (**CLASS** command).
- 3. Define the directory where the raw data files are located. (CHEF DIRECTORY command).
- 4. Select the automatic calibration mode (see the calibration section for explanation about the different calibration mode). (CHEF SUPPLY command).
- 5. Supply the ambient (outside) temperature and pressure during the observations. (CHEF SUPPLY command).
- 6. Supply the temperature of the hot (usually at the receiver cabin temperature) and cold load for the 345 GHz receiver. (CHEF SUPPLY command).
- 7. Supply the beam and forward efficiency of the telescope for the 345 GHz receiver. Set these to the same number if they haven't been measured to obtain TA* values. (CHEF SUPPLY command).
- 8. Supply the image gain ratio of the 345 GHz receiver. (CHEF SUPPLY command).
- 9. Supply a line name for the line observed with the 345 GHz frontend. This command is not compulsory; if no line name is supplied, "UNKNOWN" is written in the **CLASS** header. (CHEF SUPPLY command).

- 10. Reduce the calibration scan number 5519. Display the resulting system and receiver noise temperature (Tsys and Trec) as well as the scaling factor (Tcal). The reduction is performed for all the backends and frontends used (so the proper calibration parameters should have previously been supplied for all the frontends; in the example given, only the 345 GHz frontend was used). The results are applied to all the subsequent spectral line scans until another CALIBRATE command is issued. (CHEF CALIBRATE command).

- 11. Define the procedure used to reduce the data (which should correspond to the observing procedure used. Here PRASTER stands for position switched raster map. (CHEF PROCEDURE command).

- 12. Reduce the scan number 5520 (previous scan number + 1) and write the resulting spectra in the output Class-like file. (CHEF DORED command).

- 13. Reduce the calibration scan number 5521 with the same claibration parameter as the previous one.

- 14. Reduce the position switched raster scan number 5522.

Such a procedure reduces a complete scan, but it is also possible to reduce only 1 subscan (or 1 pair of subscans for position switching observations). In this case, the subscan is not automatically written in the output file: the **CLASS** command WRITE should be used. For example, the following procedure can be used.

```
DEVICE X IMAGE
FILE OUT TEST.SMT NEW
DIRECTORY [SMT.DATA]
SUPPLY CAL COLD
SUPPLY AMBIENT 280 670
SUPPLY CHOPPER 290 80/FE 1
SUPPLY EFFICIENCY 1.0 1.0/FE 1
SUPPLY GAIN 1.0/FE 1
SUPPLY LINE 12CO(3-2)/FE 1
CALIBRATE 5523
PROCEDURE PSWITCH
SCAN N
DOSUBSCAN 1
DOSUBSCAN 2
STORE AOS
PLOT
DOSUBSCAN 3
DOSUBSCAN 4
STORE AOS
WRITE
```

```
!
EXIT
```

In this example, the sum of the subscan 1,2,3, and 4 (1 and 3 are on the reference position) of the scan number 5524 is written into the output file for the AOS, but only the sum of the subscans 1 and 2 is plotted on the screen.

1.1.3 Spectral Line Data

The spectral line data reduction mode in **CHEF** is selected by the **CLASS** commands SET TYPE LINE (default when entering **CHEF**).

1.1.3.1 Calibration

Since **CLASS** deals with calibrated data, **CHEF** provides means to calibrate the spectral line raw data written on the disk.

The aim of the calibration is to estimate properly the noise contribution from the atmosphere and the receiver and the atmospheric transmission. **CHEF** assumes that the standard chopper wheel technique was used during the observations, which means in practice that previous to the observation of the soure, a scan was taken with one subscan on the blank sky (close to the source to have the same atmospheric conditions), one on a load at ambient temperature in the receiver cabin (the chopper wheel), and usually a third one on a cold load (if available).

The calibrated signal in the backend channel i is given by:

$$\frac{signal_i}{gain_i} * T_{cal} \tag{1.1}$$

where signal$_i$ is usually the weighted sum of the signal taken on the source position and the signal taken on a reference position (or at a reference frequency for frequency for frequency switching observation mode), gain$_i$ the gain in channel i is determined during the calibration scan (gain$_i$ is usually the backend counts on the chopper load minus the the backend counts to antenna temperature. The system noise temperature can then be derived by:

$$T_{sys} = \frac{T_{cal} * Mean\_atm}{Mean\_chop - Mean\_atm} \tag{1.2}$$

where Mean$_{atm}$ and Mean$_{chop}$ are the powers (average over all the backend channels) measured when observing the blank sky and the chopper respectively.

T$_{cal}$ is given by:

$$T_{cal} = \frac{(T_{chop} - T_{emi}) * (1. + Gain_i)}{Atts * Feff} \tag{1.3}$$

where T$_{emi}$ is the antenna temperature on the sky, Atts is the attenuation of signal through the atmosphere in the signal side band (Atts = exp(τ_s * Airmass) where τ_s is the opacity in the signal band), Gain$_i$ the image over the signal band gain ratio and Feff the forward efficiency. T_{emi} is related to the effective brightness temperature of the sky T_{sky} by:

$$T_{emi} = (1 - Feff) * T_{cab} + Feff * T_{sky} \tag{1.4}$$

where T_{cab} should be a weighted average of the receiver cabin temperature and the outside temperature (to take into account all the rearward losses). T_{emi} can be measured if the receiver temperature is known (or measured if a cold load is available). If not, T_{sky} can be evaluated with the formula:

$$T_{sky} = \frac{T_{atm_s} * (1 - exp(-\tau_s * Airmass)) + T_{atm_i} * (1 - exp(-\tau_i * Airmass)) * Gain_i}{1 + Gain_i} \tag{1.5}$$

where T_{atm_s} and T_{atm_i} are the atmospheric temperatures in the signal and image band and τ_s and τ_i the opacities of the atmosphere in the image and signal band. These parameters can either be directly supplied in the MANUAL calibration mode (SUPPLY TAU and SUPPLY ATMOSPHERE) or computed from an atmospheric model (taken from the ATM program of J. Cernicharo) and the given ambient (outside) temperature and pressure. In the latter case, if the antenna temperature on the sky T_{emi} has not been measured, the water vapor content should be supplied (SUPPLY WATER). The resulting τ_s is also used to compute the attenuation factor Atts.

So, 4 modes of calibration can be used: COLD, AUTO, TREC, and MANUAL, selected by the SUPPLY CAL command. Then, the calibration scan can be read and reduced with the CALIBRATE command and the system noise temperature, T_{sys} , the receiver noise temperature T_{rec} and the scaling factor T_{cal} are calculated and displayed for each backend part. The gain of each channel is determined for each connected backend and loaded in the gain array, which can be then displayed with the GAINS command (for checking purposes). All further data will be converted to antenna or main-beam brightness temperatures according to the beam efficiency factor defined by the SUPPLY EFFICIENCY command from these gains and the system temperature[1]

The results are also written in a formatted file: CALIBRATION.DAT.

To give meaningful results, several calibration parameters should also be supplied to the program before the CALIBRATE command is issued (the default values provided by the program are usually too far from the actual values to give sensible results), depending on the calibration mode used.

1.1.3.2 Cold load available: COLD mode

This is the most complete calibration mode, with the minimum number of assumptions, but which is possible only if a cold load (usually liquid nitrogen) is available.

For a perfectly linear detector, the receiver temperature is given by:

[1]Temperature is defined via the Rayleigh-Jeans formula, as has always been customary in Radio astronomy, and not the Planck function. Following common usage, we use the symbol Ta* to designate this quantity, where the * means that the value has been corrected for atmospheric extinction.

$$T_{rec} = \frac{T_{cold} * Mean\_chop - T_{chop} * Mean\_cold}{Mean\_cold - Mean\_chop} \tag{1.6}$$

where Mean_chop and Mean_cold are the measured powers (average counts over the backend used) on the chopper and cold load respectively, and T_{chop} and T_{cold} the physical temperature of the chopper (usually the ambient temperature inside the receiver cabin) and of the cold load (as seen by the receiver beam).

The antenna temperature on the sky is then given by:

$$T_{emi} = T_{chop} - \frac{(T_{chop} - T_{cold}) * (Mean\_chop - Mean\_atm)}{(Mean\_chop - Mean\_cold)} \tag{1.7}$$

and the effective brightness temperature of the sky, T_{sky}, is calculated using equation 3.5.

Then, the opacities and atmospheric temperatures in the signal and image bands can be derived by fitting this measured effective sky brightness temperature through the atmospheric model. The resulting τ_s is then used to compute the attenuation factor.

With this method, the parameters which have to be specified are thus:

- T_{chop}, the chopper temperature, and T_{cold}, the effective cold load temperature (SUPPLY CHOPPER command);
- T_{amb}, the outside temperature and P_{amb}, the external pressure (SUPPLY AMBIENT command);
- Feff, the forward sky coupling efficiency and eventually Beff, the main beam efficiency if main beam brightness temperature scale is desired (SUPPLY EFFICIENCY command);
- Gain_i, the ratio of the gain in the image band to that in the signal band (SUPPLY GAIN_IMAGE command).

1.1.3.3 No cold load available: TREC mode

In case the cold load is not available, there is no way to measure both the sky emission and the receiver temperature. However, if the receiver temperature is known (and stable), the sky emission temperature can be derived by:

$$T_{emi} = (T_{chop} + T_{rec}) * \frac{Mean\_atm}{Mean\_chop} - T_{rec} \tag{1.8}$$

Then one can proceed exactly as before. In this mode, T_{rec} should be supplied (SUPPLY TREC command), but T_{cold} is useless. The other parameters to be supplied are the same as in the COLD mode.

1.1.3.4 No cold load available: AUTO mode

Another alternative is to assume that the water vapor content is known, either from a previous measurement and assuming the weather is stable, or from theoretical curves as a function of pressure, temperature and relative humidity. It is then possible to derive all the other properties of the sky, total brightness and transmission in the signal and image bands. In this mode, the amount of precipitable water vapor in millimeter should be supplied with the SUPPLY WATER command, and T_{cold} is useless. The other parameters to be supplied are the same as in the COLD mode.

1.1.3.5 MANUAL MODE

Finally it is also possible to not go through the atmospheric model with specifying all the atmospheric parameters and using equation x to compute the sky emissivity.

T_{rec} can then be derived by:

$$T_{rec} = \frac{T_{emi} * Mean\_chop - T_{chop} * Mean\_atm}{Mean\_atm - Mean\_chop} \tag{1.9}$$

In this mode the parameters to be supplied are:

- T_{chop}, the chopper temperature (SUPPLY CHOPPER command);
- T_{atm_s} and T_{atm_i}, the atmospheric temperatures in the signal and image band (SUPPLY ATMOSPHERE command);
- τ_s and τ_i, the atmospheric opacities in the signal and image band (SUPPLY TAU command);
- Feff, the forward sky coupling efficiency and eventually Beff, the main beam efficiency if main beam brightness temperature scale is desired (SUPPLY EFFICIENCY command);
- $Gain_i$, the ratio of the gain in the image band to that in the signal band (SUPPLY GAIN_IMAGE command).

For more information about calibration, see Chapter **??**.

1.1.4 Standard Procedures

To be easy to use, **CHEF** can reduce data taken with some standard procedures, with only one command, the DORED command. But this means that the data should have been taken with the same procedure as defined with the PROCEDURE command. The procedures are also used by the DOSUBSCAN command. This command allows to reduce each subscan (or pair of subscans) separately, and is the one used for the on-line display. But, to write the spectra in the output file, the STORE command and the subsequent WRITE command of **CLASS** should be issued for each backend part.

Presently, 7 standard procedures are defined in CHEF PSWITCH, FSWITCH, WSWITCH, PRASTER, FRASTER, WRASTER, and PMAP.

1.1.4.1 PSWITCH

This procedure defines a position switching observation, with subscans taken in total power alternatively on a reference position and on the source position, starting with a subscan on the reference position.

1.1.4.2 Procedure FSWITCH

This procedure defines a frequency switching observation. Each subscan should have 2 phases, the first one at the signal frequency and the second at the reference frequency.

1.1.4.3 Procedure WSWITCH

This procedure defines a wobbler switching observation, that is a position switching observation with the wobbling secondary reflector. Each subscan should have 2 phases, one on the source position and one on a reference position at the wobbler throw distance from the source. The subscans are taken alternatively with telescope pointing at minus and plus the wobbler throw distance from the source, so that the reference positions are alternatively at each side of the source.

1.1.4.4 Procedure PRASTER

This procedure defines a position switching raster map observation. It is similar to the procedure PSWITCH with the only difference that a subscan on the reference position may be followed by several subscans on the source positions.

1.1.4.5 Procedure FRASTER

This procedure defines a raster map observation in frequency switching mode. The only difference with the FSWITCH procedure is that **CLASS** spectra are written for each subscan separately when using the DORED command.

1.1.4.6 Procedure WRASTER

This procedure defines a raster map observation in wobbler switching mode. The only difference with the WSWITCH procedure is that **CLASS** spectra are written for each subsan separately when using the DORED command.

1.1.4.7 PMAP

The procedure defines a position switching sweep map observation. The difference with the PRASTER procedure is that the telescope is assumed to have sweeped through the source during the ON-source subscan, and so, each raw data dump is reduced separately (one **CLASS** spectrum for each). This procedure allows much faster mapping but the effective telescope beam is broadened.

1.1.5 Continuum Procedures

As **CLASS** does not provide any reduction treatment for ON-OFF or raster maps continuum procedures, no reduction is presently provided by **CHEF** for this type of observation. But **CHEF** provides a reduction for the basic telescope calibration procedures performed in continuum mode: pointing, focusing and skydips.

1.1.5.1 Pointing

The pointing reduction mode is selected in **CHEF** by the **CLASS** command SET TYPE CONT. The SCAN command should be issued to start the reduction of a scan, and then the SUBSCAN command. This command works a little differently than in the line reduction mode. First, the option /SIGNAL has no meaning, and the second the SUBSCAN command just reads the subscan but does not store it or make average with the previous subscan, the command STORE should then be issued. To perform the gaussian fit and to calculate the pointing corrections, two internal data arrays are kept in parallel, one for the azimuth subscans and one for the elvation subscans, for the backend and backend part (channel) for which the gauss fit and computing of the pointing correction is desired. This backend and backend part should be supplied by the SUPPLY POINTING command. This allows a write to all backend parts in the **CLASS** output file, but to perform the gauss fit only on one part.

The STORE command resamples the data on a regular grid, and if the backend part corresponds to the one defined by the SUPPLY POINTING command, performs a gauss fit and displays the results on screen. To get the average and the computing of the pointing corrections, the POINTING command should then be issued at the end of the scan.

Here is an example of a **CHEF** procedure for a standard 4 subscans pointing cross-scan (with scanning successively back and forth in each direction), with writing each subscan (both backend parts) in the **CLASS** output file, and perform the calculation of the ponting corrections on the first continuum backend part (the continuum backend is defined as backend number 1):

```
CHEF> DEVICE X IMAGE
CHEF> FILE OUT TEST.SMT NEW
CHEF> DIRECTORY KDATA:[SMT.DATA]
CHEF> SET TYPE CONT
CHEF> SUPPLY POINTING 1 2
CHEF> SCAN 9416
CHEF> SUBSCAN
CHEF> STORE CONT 1
CHEF> WRITE
CHEF> STORE CONT 2
CHEF> WRITE
CHEF> SUBSCAN
CHEF> STORE CONT 1
CHEF> WRITE
```

```
CHEF> STORE CONT 2
CHEF> WRITE
CHEF> SUBSCAN
CHEF> STORE CONT 1
CHEF> WRITE
CHEF> STORE CONT 2
CHEF> WRITE
CHEF> SUBSCAN
CHEF> STORE CONT 1
CHEF> WRITE
CHEF> STORE CONT 2
CHEF> WRITE
CHEF> POINTFIT
CHEF> !
CHEF> EXIT
```

It is also possible to calibrate pointing scans in the same way a spectral data. The CALIBRATE command should be issued after the SET TYPE CONT command (and of course be applied on a continuum calibration scan). The only difference with spectral line calibration is that the signal is assumed to come from both sidebands. Once a continuum calibration reduction has been performed in **CHEF** the results are applied to all subsequent scan reductions.

1.1.5.2 Skydips: Not Implemented in CHEF

Skydips allow one to simultaneously derive the water vapor content of the atmosphere and the forward efficiency, if a cold load is available (or if the receiver temperature is known for the TREC mode). The skydip reduction mode is selected in **CHEF** by the **CLASS** command SET TYPE SKY.

The reduction assumed that a first scan was taken with one subscan on the chopper load and the second subscan of the cold load. The CALIBRATE command should be issued to reduce this calibration scan. In the COLD calibration mode, the following parameters should be supplied:

- T_{chop}, the chopper (also called hot load) temperature and T_{cold}, the effective cold load temperature (SUPPLY CHOPPER command).
- T_{amb}, the outside temperature and P_{amb} the external pressure (SUPPLY AMBIENT command).
- $Gain_i$, the ratio of the gain in the image band to that in the signal band (SUPPLY GAIN_IMAGE command).

In the TREC mode the receiver temperature should be supplied instead of the cold load temperature.

Then, the skydip scan itself can be reduced with the SCAN command and subsequent SUBSCAN commands for each subscan. **CHEF** assumes that the skydip scan consists of several subscans taken on the blank sky at different elevations.

The STORE command fits the right hand of equation x to the measured powers, taking the previous water vapor content as a starting point (1 mm at the beginning of a **CHEF** session), plot the data, and the fit results on screen and write the results in an output formatted file SKYDIP.DAT.

If a **CLASS** output file was opened, the value of the powers on the chopper load, the cold load and on the sky, as well as all the relevant calibraion parameters can then be written in the **CLASS** output file for eventual further reduction with the WRITE command.

A typical **CHEF** procedure for reducing a six subscan skydip is:

```
CHEF> DEVICE X IMAGE
CHEF> DIR KDATA:[SMT.DATA]
CHEF> SUPP AMB 280 702
CHEF> SUPP CHOP 295.3 103/FE 1
CHEF> SUPP GAIN 1.0/FE 1
CHEF> SET TYPE SKY
CHEF> CAL 7538
CHEF> SUPPLY WATER X
CHEF> SCAN N
CHEF> FOR I 1 TO 6
CHEF> SUB
CHEF> NEXT
CHEF> STORE CONT 1
CHEF> WRITE
CHEF> !
CHEF> EXIT
```

As shown in this example, it is usually better to issue twice the STORE command the first time (for each frontend) as the previous water vapor content value might be quite far from the actual one. This is usually the case at the beginning of a **CHEF** session where this value defaults to 1 mm. Another possibility is to use the SUPPLY WATER command (as shown in the example) to give reasonable starting values.

1.1.5.3 Focusing

Although no data reduction is provided in **CLASS**, an independent reduction procedure exists in **CHEF**. It is simply performed by issuing the FOCUS command with the relevant scan number as the argument. **CHEF** assumes that the focusing scan consists of 6 subscans taken on the blank sky with moving the subreflector in a certain distance L back for the first subscan, at the central position for the second subsca, forth at the distance L for the third and forth subscans, again at the central position for the fifth subscan and at a distance L back for the sixth subscan. A parabola is fitted on the masured powers and the needed focus correction is calculated for each receiver. The results are displayed on screen and written in an output formatted file FOCUSING.DAT. The same command can also be used for the same type of scan with moving the subreflector perpendicular to the radial axis (in the Y direction).

1.1.6 CHEF Internal Help

1.1.6.1 CALIBRATE

```
CHEF\CALIBRATE nscan
```

Reduces a calibration scan according to the calibration mode defined by the SUPPLY CAL command and using the calibration parameter defined by the SUPPLY AMBIENT, SUPPLY EFFICIENCY, SUPPLY CHOPPER, SUPPLY GAIN, SUPPLY WATER, etc commands. Although some default values are provided for all the calibration parameters, the program can even crash (with some integer or floating point overflow usually) if these values are too far from the actual ones.

Nscan is the scan number or "next" to reduce the next scan number.

CALIBRATE assumes that the first subscan was performed on the sky, the second on the hot (ambient) load and eventually the third on the cold load for spectral line data and continuum drift. For skydip (SET TYPE SKY mode), CALIBRATE assumes that the first subscan was performed on the hot (ambient) load and the second on the cold load.

1.1.6.2 DIRECTORY

```
CHEF\DIRECTORY name
```

Define the directory where the raw data are. Default is KDATA:[SMT.DATA]: (the colon is compulsory when a logical name is used for directory).

1.1.6.3 DORED

```
CHEF\DORED Scan [Subscan]
```

Reduces a complete scan according to the procedure defined by the PROCEDURE command. The reduced spectra are automatically written in the output file (which should have been opened before with the FILE command of **CLASS**). Scan is the scan number or "next" to reduce the next scan number. Subscan is the subscan number from which the reduction starts (defaults to 1).

The DORED command is equivalent to the list of following commands:

```
SCAN Scan
DOSUBSCAN
DOSUBSCAN
```

```
.... !(as many DOSUBSCAN as subscans number)
STORE nback ipart !(for each backend)
WRITE !(for each backend)
```

1.1.6.4 DOSUBSCAN

```
CHEF\DOSUBSCAN [nsub] [ndump]
```

Read and reduces a subscan according to the procedure defined by the PROCEDURE command. The SCAN command should have been entered before to give the scan number. The subscan can then be stored in the R buffer by the STORE command in order to be plotted or written in a file. Nsub is the subscan number and defaults to previous subscan number + 1. (the previous subscan number is reset to 0 after a SCAN command). Ndump is the dump number for the procedures which reduce each dump separately (e.g. sweep mapping procedures). It defaults to the previous dump number+1 (the prevous dump number is reset to 0 after a SCAN command). The ndump argument has no meaning for the procedures which reduce a full subscan.

1.1.6.5 FOCUS

```
CHEF\FOCUS nscan
```

Reduces a focusing scan. Assumes that 6 subscans were taken with offsetting the secondary reflector respectively at -L, 0, L, L, 0, -L millimeter (L is the value chosen by the observer) in the X or Z direction. A parabola is fitted and the resulting needed correction is calculated. All the frontends used are reduced. The results are displayed and written in the FOCUSING.DAT file (formatted file). Nscan is the scan number or "next" to reduce the next scan number.

1.1.6.6 GAINS

```
CHEF\GAINS nback
```

Plot the gains value versus the channel number (in raw data order) for the specified backend. The backend name or the corresponding backend number nback should be specified (no default).

1.1.6.7 POINTFIT

```
CHEF\POINTFIT
```

Performs a gaussian fit on the average of the pointing subscans in azimuth and elevation and computes the pointing corrections, for the backend and backend part (channel) selected by the SUPPLY POINTING command (defaults to backend number 1 and part number 1).

1.1.6.8 PROCEDURE

```
CHEF\PROCEDURE name
```

Define the procedure used to reduce the raw data with the DORED and DOSUBSCAN command. Seven standard procedures are currently implemented:

- 1. PSWITCH for a position switching observation mode.
- 2. FSWITCH for a frequency switching observation mode.
- 3. WSWITCH for a wobbler switching observation mode.
- 4. PRASTER for a position switching raster map.
- 5. FRASTER for a frequency switching raster map.
- 6. WRASTER for a wobbler switching raster map.
- 7. PMAP for position switching drift map.

The default is PSWITCH.

1.1.6.9 SCAN

```
CHEF\SCAN nscan
```

Reset the scan number to nscan and initialize the signal and gains arrays. The current subscan number is reset to 0, and subscans may then be read in by the DOSUBSCAN or SUBSCAN commands.

1.1.6.10 SHOW

```
CHEF\SHOW [Arg]
```

Displays the specified parameter (see the SUPPLY command for a list of possible parameters). If Arg is ALL, all **CHEF** parameters will be listed. Note that you should specify the language because this command is ambiguous with the LAS SHOW command.

1.1.6.11 SIGNAL

```
CHEF\SIGNAL nback
```

Plot the signal array values versus the channel number (in raw data order) for the specified backend. The backend name or the corresponding backend number nback should be specified (no default).

1.1.6.12 STORE

```
CHEF\STORE nback [ipart]
```

STORE processes the part ipart (default to 1) of the backend nback (name or number) and copies it in the R buffer of **CLASS**. It can then be further analyzed by standard **CLASS** commands, plotted (PLOT command) or written (WRITE command) in the output file for example. The backend name or the corresponding backend number nback should be specified (no default).

STORE is the necessary step to produce a spectrum after DOSUBSCAN command(s).

1.1.6.13 SUBSCAN

```
CHEF\SUBSCAN [nsub] [ndump] [/SIGNAL w1 [w2 [...]]]
```

Read the subscan number nsub of the current scan. Nsub default to the current subscan number incremented by one. If a dump number is specified, **CHEF** assumes that the dumps are to be reduced separately for this subscan command and the following. For the following SUBSCAN commands, the dump number need not be specified and defaults to the previous dump number + 1 (even if the subscan number is incremented). To reset the standard mode in which all the dumps of the current subscan are summed, the SCAN command should be typed again.

The SIGNAL option is used to indicate how to increment the signal array by the weighted sum of the available phases in this subscan, with weights w1, w2, ...

For pointing and skydip procedures, SUBSCAN should be issued to read and reduce a subscan (no DOSUBSCAN and DORED commands). In this case the dump number and the SIGNAL option have no meaning.

For spectral line observations, it's rather recommended to use the DOSUBSCAN (or DORED) command, unless a non-standard observing procedure was used.

1.1.6.14 SUPPLY

```
CHEF\SUPPLY something [value1 [value2 [...]]] [/FE 1]
```

This command is used to introduce the calibration parameters as well as the observation parameters which are not included in the raw data header (if any). The /FE option specifies the fontend name or corresponding number for which the parameter is valid.

```
AMBIENT temp pressure : ambient temp (K) and pressure (mbar).

ATMOSPHERE sig img : atmospheric temperature (absorbing
         layers), in both sidebands (for MANUAL calibration).
CAL mode : calibration mode to be used: AUTO (default),
  COLD, TREC or MANUAL.
CHOPPER Thot Tcold : Hot and cold load temperatures (K).
```

```
EFFICIENCY beam forward : antenna beam efficiency, and forward (sky)
  efficiency
GAIN_IMAGE gain_i : gain in the image band to gain in the signal band
  ratio
LINE name : enters a name for the observed line (useful for
  book-keeping purposes)
POINTING ib ipart : select the backend part for the pointing
  corrections.
TAU sig img : optical depth in Signal and Image Bands (for
  MANUAL calibration mode).
TREC trec : receiver temperature (for TREC calibration mode).
WATER wH2O : amount of precipitable water vapor in the
  atmosphere (for AUTO and MANUAL calibration modes).
```

If a * is typed instead of an argument value, the previous value is kept. Since the ambient temperature and pressure don't depend on the frontend used, the FE option is meaningless for the SUPPLY AMBIENT command. Also, the same calibration mode is used for all the frontend, so the FE option is not taken into account for the SUPPLY CAL command.

1.2 TOOLBOX

TOOLBOX is a powerful pair of programs for both spectral line (SPEC2) and continuum (CONT2) reduction. The documentation for this package is too large to be included in this volume. Binders with this information are available at the site and in Tucson.

Currently only CONT2 is implemented at the SMTO. See Appendix **??** for a quick guide to some basic operations in CONT2.