Chapter 11

Calibration in Practice

Anne Dutrey & Roberto Neri

IRAM, 300 rue de la Piscine, F-38406 Saint Martin d'Hères

11.1 Introduction

11.1.1 Contents of the account

At the first login on a new project account, you should find five directories:

1. `reports`: It contains all the pre-calibration performed by the Astronomer on Duty (AoD) on the site. This subdirectory is in read access only. For a given observing date, you should find the following compressed files: `28-feb-2001-x007.hpb.gz`, the header file containing the calibration curves of the data; `28-feb-2001-x007.ps.gz`, the PostScript file containing the result of this calibration. This file should be carefully read before starting a new calibration. `show-28-feb-2001-x007.ps.gz` is the PostScript file corresponding to a first look of the data. It includes meteo conditions (wind, mm of water, system temperature) but also pointing and focus errors. In many cases, this file can help to interpret dubious data. This file should also be read carefully before starting calibration. The file `x007.note` are notes written by the AoD on the site. This file is updated at each period of observations. It gives important information about the data quality and possible problems.

2. `headers`: It initially contains a copy of reports. Files should be uncompressed and data calibration should be performed in this subdirectory. This is the default directory of CLIC. However before activating CLIC, it is better to move to this subdirectory using the shell command: `''cd /headers''`.

3. `maps`: This subdirectory, empty at the beginning, should contain at the end all the *uv* tables and the maps produced. Using the CLICprocedure `''Write A UV Table''`, the *uv* tables are created by default in this directory which is also the default directory for GRAPHIC and MAPPING.

4. `tmp/DATA`: This subdirectory contains the raw data files (IPB) and their corresponding log files. In the example presented above, it would contain: `H228X007.IPB, H228X007.OBS, H228X007.RDI`. Access to this directory and to the raw data files is automatically handled by CLIC.

5. `DATA`: Most of the time this directory is empty. However, it can contain some IPB files and their corresponding log files. Like in the case of `tmp/DATA`, its use is transparent. The reducer does not need to know the exact location of the raw data files on her/his account. CLIC handles it for him/her.

Note that only the directories `reports`, `headers` and `maps` are saved on CDroms by the automatic procedure `savproj`.

11.1.2 Before starting the data reduction

The compressed PostScript files in `headers` containing the calibration curves performed by the AoD must be *gunzip*ped and printed. Then, they must be carefully studied in order to determine the general quality of the data and find possible problems which are usually mentioned in the `project.note` file (*e.g.* `x007.note`) written by the AoD during the pre-data reduction process.

11.1.3 Activating the CLIC environment

CLIC is available by typing in the directory `headers`

`$ CLIC`

Under CLIC, there are several procedures available:

1. `File`: To open a new header (hpb) or data (IPB) file
2. `Raw Data File`: To open a raw data file (IPB)
3. `Raw Data File Directories`: To define the location of raw data file directories
4. `First Look`: Instrumental and meteorological conditions during the observations (see §2)
5. `Standard Calibration (2 receivers)`: To calibrate raw data (see §3)
6. `Self-Cal on a point source`: To self calibrate the phase
7. `Simple Check`: To do simple checks on the data
8. `Holography Reduction`: To reduce holographic data
9. `Write A UV Table`: To produce the visibility table

Useful procedures to calibrate data are 1) `''First Look''`, 2) `''Standard Calibration (2 receivers) ''` and 3) `''Write A UV Table''`.

11.2 The "First Look" procedure

The procedure `''First Look''` provides information about the weather conditions and a few instrumental parameters at the time of the observations. This information is very important as it helps you to make a first data quality assessment even before you may start with the interactive data calibration procedure. The panel of the procedure is shown on Fig.11.1.

Monitoring information is provided on:

- `Meteorology:` the average and maximum wind velocity, the ambient pressure and temperature. Gusty conditions and observations with wind velocities above 10 m/s may show up with high pointing corrections. Take care to tag visibilities which may be affected by such difficult observing conditions.
- `Pointing and Focus:` the applied corrections are shown for all the antennas in the array. Only differential variations in the corrections play a role, not the absolute amount. Sudden pointing corrections by more than $10''$ can considerably spoil the visibilities, especially at the highest observing frequencies. A similar consideration applies for antenna focus corrections, although visibilities are automatically corrected for phase offsets which are generated by focus corrections.

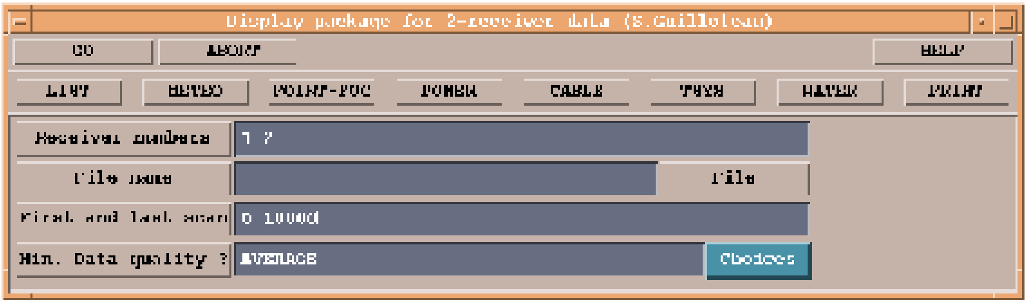

Figure 11.1: "First Look" panel

- `Total Power`: a trace of the total incident atmospheric power recorded by the continuum detectors (one for each receiver, each one second), helps in further evaluating the data quality. As a rule, strong and rapid variations in the total power trace the presence of clouds in the line of sight while a sudden up- or down-stepping on one antenna and on one receiver is a sign of a renewed receiver tuning. The total power increases in general with the air mass.
- `Cable Phase`: variations in the electrical length of the cables show up in phase variations (referenced to the LO2 phases). These are measured by a phasemeter. Appropriate corrections for the phases of the LO1 rotators are computed taking $n$times the corrections measured by the phasemeters of the 3 mm receivers and 3 n times the corrections measured by the phasemeters of the 1 mm receivers, where n is the harmonic number of the tuned frequency. Strong and rapid variations while a source is tracked may indicate a fault in a cable (these data should perhaps be flagged), whereas a sudden but steady change is mostly related to a shift in the antenna pointing.
- `System Temperature`: dependent on the observing conditions and on the frequency. As for the total power detectors, strong and rapid variations in the system temperature trace atmospheric instability, whereas a sudden but steady change on one receiver is a sign of a renewed receiver tuning.
- `Water vapor`: the content of precipitable water vapor in the atmosphere is a critical parameter on which the quality of most of the high frequency observations depend. Should the measured water vapor content not be consistent (or roughly) on all the high frequency receivers, please check the receiver gain.

Finally, the "First look" procedure produces a short list of all the scans recorded at the time of the execution of a project. Such a listing allows you to trace back the sequence of operations during an observing run. Note that the range of scan validity for the calibration procedure sets up with the last `GAIN` scan in the short list.

Looking at the results of the procedure (called in the example above `show-28-feb-2001-x007.ps.gz`) should be done simultaneously with the reading of the project.note file (here `x007.note`).

11.3 The "Standard Calibration (2-receivers)" procedure

We describe here, step by step the inputs and actions (or outputs) of the procedure `''Standard Calibration (2 receivers)''`. The associated panel is given in Fig.11.2.

11.3.1 Inputs

On the panel, the reducer should select with the mouse the `''File name''` of the header file. Other parameters are automatically selected by the procedure if the flag `''Use previous settings''` is set to `YES` which is the default. Never change it if your data are correct (no editing). The parameters `''First`

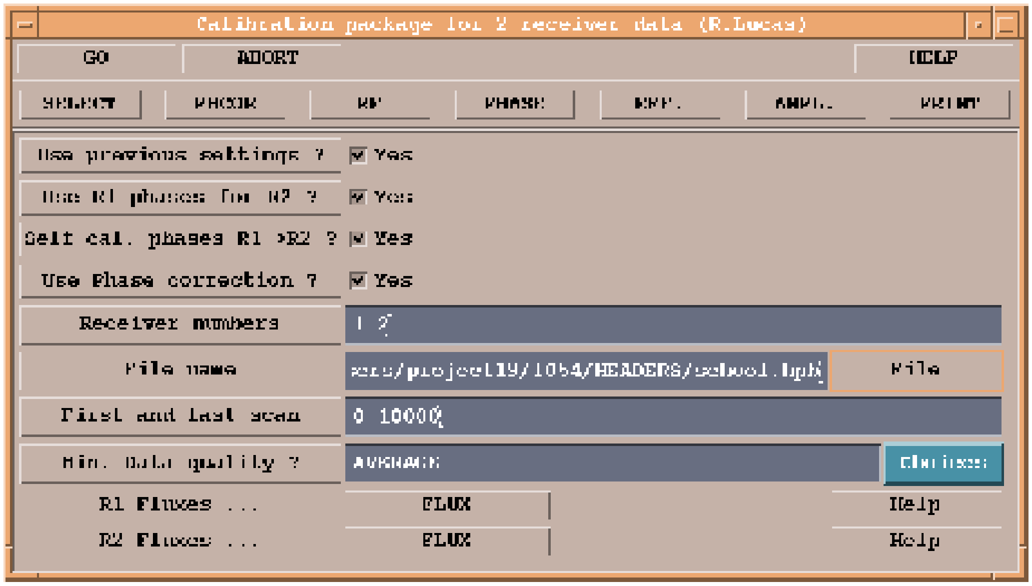

Figure 11.2: "Standard Calibration (2 receivers)" panel

and last scan'' are selected automatically when **''Use previous settings''** is set to **YES**. The default value for the flag **Min.Data quality** is **AVERAGE**. The flag **''Use Phase correction''** must also be set to the default: **YES**. The current procedure uses by default the phase calibration of the receiver 1 to calibrate the instrumental phase of the receiver 2 because the experience has shown that it is the more efficient way to proceed (see R.Lucas lecture on phase calibration). Therefore, the calibration of the receiver 2 (1.3 mm) cannot be dissociated from the calibration of the receiver 1 (3 mm) and the flag **''Receivers numbers''** must be set to **1 2**, except when observations were done at 3 mm only.

Finally, the inputs **''R1 Fluxes''** and **''R2 fluxes''** are associated (when needed) to the action **EFF**)

11.3.2 Actions or Outputs

To calibrate your data, you need to do the following actions leading to the output calibration, in order:

1. **SELECT**: Select the calibration parameters
2. **PHCOR**: Radiometric phase correction, equivalent to a **''Monitor 0''**, see A.Dutrey lecture.
3. **RF**: Radio Frequency calibration
4. **PHASE**: Instrumental phase calibration versus time
5. **EFF**: Efficiency (Jy/K) calibration, to determine the flux densities of the amplitude calibrator. The inputs **''R1 Fluxes''** and **''R2 Fluxes''** should be used here.
6. **AMP**: Amplitude calibration versus time
7. **PRINT**: To produce the LaTeX and PostScript files containing the calibration curves (*e.g.* `28-feb-2001-x007.ps`).

By typing **GO**, all the actions listed above are done sequentially. The reducer has just to type `continue` under CLIC (or use the "Continue" button in the top left menu) at each step of the calibration process.

11.3.3 Results of the calibration

After a few general comments about quality of the data, including the measurement of the seeing (deduced from the rms of the fit of the temporal phase), the pages 1 and 2 summarize the calibration as follows:

- §1.1 The estimated flux densities of the calibrators at the observed frequencies.
- §1.2 The efficiencies of the antennas for Receiver 1 and 2 (which are deduced by fixing the flux of one or several calibrators).
- §1.3 The hour angle observed on the source
- §1.4 The table of the rms obtained on the RF calibration for receivers 1 and 2 in both upper and lower sidebands
- §1.5 The table of the rms obtained the temporal fit for the phase and the amplitude per baselines. Note that for receiver 2, the rms given in Col.1 is exactly the product of frequency ratio (rece 2/rece 1) times the rms obtained on receiver 1 because the phase on the receiver 1 is used to calibrate the phase on the receiver 2. After applying this phase correction, a second fit is performed on the residuals, its rms is displayed on Col.2. Col.3 gives the rms obtained on the amplitude (in %).