paKo
The Observer's User Interface to the New Control System at the IRAM 30-Meter Telescope

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Description - about this document:
This is the documentation of the observer's user interface to the New Control System (NCS). The user IF program is nicknamed "PAKO" = "paKo for astronomers' K(c)ontrol of observations".
Revision v 1.1.14 introduced support for NIKA, and SUBSCAN /TUNE for NIKA.
Revision v 1.1.15 supports the upgrade of EMIR band E150 to full 2*2*8 GHz LSB+USB in both polarizations, and the E330 local oscillator to higher frequencies (2013-09).

README. Observers who are new to the NCS are encouraged to read sections 1, 2, and **??**. *Note that much of the space in these sections is taken up by examples, so the actual text is not very long or hard to read!*

References and Related Documents—Short List:

1. New Control System for the 30m Telescope

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1 paKo— Introduction and Overview

After this introduction follows section 2, a "Guide for the Perplexed". Here we briefly explain some general features of PAKO as well as differences from the previous control system for the 30-M Telescope.

In Section 3 we give a very short recipe with the bare minimum to get started with Heterodyne observations.

Section **??**, is "PaKo's Cook Book". It is meant to evolve into a gentle step-by-step and command-by-command explanation of how to do observations with the NCS.

Next is the "NCS User's Guide", **??**, which follows the same outline as the "Cook Book", but includes more details. The examples included here are all in the form of PAKO command language scripts.

The section "NCS Explained", 6, contains detailed explanations of some aspects of the NCS.

Finally, the "PAKO Language Internal Help" is reproduced in section 7.

A lot of information is intentionally duplicated in different sections of this manual, so that, e.g., the "Cook Book" and the "User's Guide" can be read independently. It should not be necessary to read all sections in this manual! Also much space is taken up by examples, so the actual text to read is not very long!

We recommend that all users who face the NCS for the first time should read the "Guide for the Perplexed". Beginning observers and those who like to set up their observations one command at a time can then follow the "Cook Book", section **??**.

More experienced observers may prefer the "User's Guide", section **??**, especially those who need more advanced options and those who like to prepare scripts with the specifications of their observations (recommended!).

All users may want to consult the section 6 "NCS explained" for general information, or look up details in the `HELP` section, 7, which is a complete reference for all commands and options.

Before starting observations, users should also review the up-to-date notes on the NCS wiki pages at:
NCS Wiki at https://mrt-lx1.iram.es/mainWiki/FrontPage

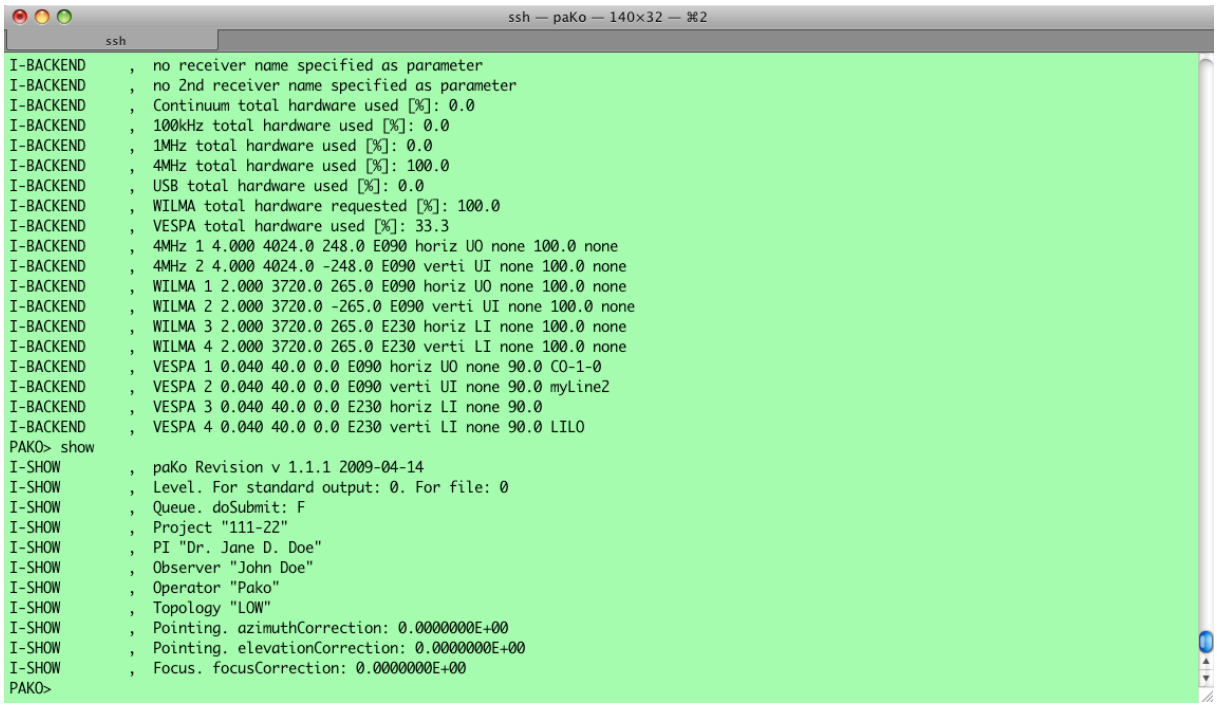

Figure 1: Screen shot of PAKO runing in a terminal window.

2 paKo — Guide of the Perplexed

2.1 paKo and SIC

PAKO uses the usual SIC command line interpretor, and can be run in any X-windows terminal, see Figure 1.

It includes the GREG and GUI languages for plotting and, of course, adding GUI widgets.

2.2 paKo and Linux

PAKO and the NCS run on Linux. Any files that are prepared off-line, e.g., command scripts and source or line catalogs, should follow Linux standards. (Files prepared on other operating systems may contain non-compliant control characters.)

2.3 Running paKo offline and several instances of paKo

PAKO can run independently of the NCS. This is useful, e.g., to prepare command scripts and source or line catalogs.

Several instances of pako should not be run in the same working directory (of the same project account.) Also, at most one instance of pako should try to send observations to the observation queue; other instances should `SET DOSUBMIT NO`, see below.

2.4 Help

There is help available, e.g., enter at the prompt `PAKO >` :

```
HELP CALIBRATE
```

The display for most commands corresponds directly to the syntax of the command. E.g., for each observing mode, the display shows the syntax of all options.

The most recent command, as pako interpreted it, is usually shown at the bottom of the display window.

The keywords for commands and options try to be meaningful and, if possible, self-explanatory. As usual with SIC, minimum match is supported, so you can also write compact (and cryptic) commands, e.g., enter at the prompt `PAKO >` :

```
OTF /B /C CROOR /NO 12 /REF /ST -20 20 /SY PR /TO 30 /TR 22 /Z
```

2.5 SET LEVEL for Errors, Warnings, and Infos

PAKO can be very "chatty" and display many "messages" in the command line window. They are marked with "I-" for "info", "W-" for "warning", or "E-" for "error". "E-" "error" is reserved for true errors, something not accepted by PAKO.

You can control the number of messages you see with with `SET LEVEL`, e.g.,

```
SET LEVEL 1 1
```

will enforce that you get all messages.

```
SET LEVEL 3 3
```

will supress most "I-" infos.

```
SET LEVEL 5 5
```

will supress most "I-" infos and "W-" warnings.

At this time (2013-10-17) PAKO still displays some debug messages, which are not flagged "I-", "W-", or "E-". They will be eliminated as soon as possible.

2.6 Saving and Restoring

For most commands you can save the parameters into a file, e.g., enter at the prompt `PAKO >` :

```
SAVE POINTING
```

This saves the parameters of observing mode `POINTING`. The format of the saved files is that of a valid script in the command language. Therefore you can restore it later: enter at the prompt `PAKO >` :

```
@ POINTING
```

In a similar way, you can save the parameters of the source, receiver and backend setup, and of the switching mode.

```
SAVE ALL
```

saves (nearly) all current parameters, as well as the current switching and observing modes. It saves the pointing and focus corrections only if used in the form:

```
SAVE ALL C[ORRECTIONS]
```

Normally `SAVE ALL` is meant to generate a paKo script that can be used to re-produce the setup at a later time, when one probably wants to use different pointing and focus corrections. On the other hand the idiomatic usage:

```
SAVE ALL C /FILE LAST
```

allows to save "really everything" in order to recover it with @ LAST.

The parameters of "unused" (unselected) hardware, switching modes, and observing modes are never saved.

Tip: check out the options of command save: enter at the prompt `PAKO >` :

```
HELP SAVE /FILE
HELP SAVE /APPEND
```

After using @ ... to restore a saved observing mode, e.g., otfmap, the graphic display may look confused. To clean it up, enter at the prompt `PAKO >` :

```
CLEAR PLOT
BOX
OTFMAP       ! i.e., the observing mode.
```

2.7 Observation Queues and Starting

In the NCS, all observations are handled through an observation queue. So far this is rather simple, first-in-first-out.

The operator has to set the "current observation queue" to be that of the project account. (Submission from other projects will not be accepted by the NCS).

enter at the prompt `PAKO >` :

```
SET doSubmit yes
```

to activate submission of observing commands to the NCS observing queue. `SET doSubmit no` is useful for debugging, so that scripts including `START` can excute without actually trying to submit observations.

To start any observation in the NCS enter at the prompt `PAKO >` :

```
START
```

which actually generates an XML file with a full and detailed specification of all subscans that will be excuted by the NCS "coordinator" software. This is done by the "scanAnalyzer", which is an integral part of the pako software. If you are looking for an adventure, you are encouraged to explore these XML files, e.g., using a recent version of Mozilla, the XML editor oxygen, or emacs.

Several instances of pako should not be run in the same working directory (of the same project account.) Also, at most one instance of pako should try to send observations to the observation queue.

2.8 Source and Line Catalogs

The format of the source catalog, e. g., iram.sou, is similar to source catalogs at PdB. A source catalog for the NCS can be generated from standard "old" 30m catalogs (*.cat) using ASTRO. The example source catalog, demo.sou, was generated from a historic version of IRAM.CAT using ASTRO.

The format of the line catalog, e. g., model.lin, is as in the old control system and at PdB.

NOTES. *In source names, line names, and parameters of type character, like Project ID, names of PI, observer, operator, one can not use characters that have a special meaning in XML, in particular don't use:* & < or >; *also don't use:* (or) *in source names.*

2.9 Switching Modes

In the NCS we distinguish the following 4 "Switching Modes":

TOTAL POWER
BEAM SWITCHING
WOBBLER SWITCHING
FREQUENCY SWITCHING (only with heterodyne receivers)

The corresponding commands are:

```
SWTOTAL
SWBEAM
SWWOBBLER
SWFREQUENCY
```

BEAM SWITCHING, WOBBLER SWITCHING, and FREQUENCY SWITCHING are realized by a system with hardware synchronization signals that allow a precise and fast switching *within* subscans.

TOTAL POWER simply means that none of the other 3 switching modes is active.

The system switches through a regular cycle with several (1, 2, or 4) switching phases.

The 4 switching modes are mutually exclusive, i.e., at any time the system uses only one of them.

During the transitions between phases, e.g., while the Wobbler is moving between its positions, no data are taken during the short "blanking" time.

The switching mode and its parameters should normally be set before choosing an observing mode, because for some observing modes details of the setup depend on the switching mode.

2.10 Observing Modes

The NCS supports the following "Observing Modes": `CALIBRATE`, `POINTING`, `FOCUS`, `TIP`, `ONOFF`, `OTFMAP`, `<<TBD:RASTER` not yet implemented `>>`, `TRACK`, `VLBI`.

All Observing Modes are realized by executing a sequence of 1 or more subscans. In most cases, the antenna moves between or during the subscans.

The observing modes are mutually exclusive, i.e., at any time the system executes only one of them.

Several Observing Modes can be combined with different Switching Modes, e.g., `OTFMAP` with TOTAL POWER, WOBBLER SWITCHING (for bolometer), or FREQUENCY SWITCHING. The Switching Mode should normally be specified before the Observing Mode.

2.11 Combinations of Switching and Observing Modes

The Switching modes and Observing modes are not fundamentally different from what they were in the old CS. However, in the NCS we try to be more explicit about this distinction in order to: (i) avoid having several commands that set up, e.g., parameters of the Wobbler, (ii) to support more combinations of Observing Modes and Switching Modes in the future.

2.12 Coordinate Systems, Map Projections, and Position Offsets

For a more detailed explanation, see Section 6.1.

The NCS will support a variety of astronomical coordinate systems and projections, as well as "descriptive" coordinate systems defined by the user. Up to now, 2013-10-17, only equatorial coordinates, J2000.0, are well tested and available for use.

Map Projections and Offsets. In general, a "map projection" describes the relation between 2 spherical coordinates, longitude l and latitude b, [1] on the celestial sphere, and 2 Cartesian coordinates x and y, which in radio astronomy and the NCS we often call "position offsets".

Up to now, 2013-10-17, only the **"radio"** projection is supported, for which:

$$x = (l - l_{source}) * \cos(b)$$

$$y = b - b_{source}$$

where l_{source} and b_{source} are the source coordinates specified with `SOURCE`. [2] Note that this is the same system of offsets as in "OBS" of the old control system.

If we want to observe several positions on the sky at or near the source position as specified with `SOURCE`, we often do this by requesting position offsets in the map projection. Also, the resulting data, *e.g.*, images, are usually stored and displayed as a function of x and y.

For most observations, parameters and options of the observing mode are sufficient to specify the position offsets:

- for `TRACK` and `VLBI` x and y are fixed during the complete scan;
- for `ONOFF` x and y change from subscan to subscan;
- for `OTFMAP` x and y change continuously or "on-the-fly" (OTF) during the OTF subscans.

The PAKO commands for most Observing Modes expect fixed offsets (or start- and end-offsets for `OTFMAP`) as parameters. These can be either in the radio projection, specified with the option:
`/SYSTEM projection`
or in the true angle horizon system (see below), specified with the option:
`/SYSTEM trueHorizon`

NOTES. For POINTING, the OTF offsets are always in system trueHorizon, and are specified implicitly though the angular length of the subscans.

[1] In particular for equatorial coordinates, l corresponds to Right Ascension and b to Declination.
[2] For the equations all angles are assumed to be in radian.

Global Offsets. On the other hand, the command `OFFSETS` can be used to specify additional position offsets in other systems. These globally defined offsets stay fixed during a complete scan. *They are only needed in special cases,* e.g.*, the Nasmyth offsets or for ONOFF with wobbler switching*, see below.

At this time (2013-10-17), the command `OFFSETS` supports offsets in the following 3 systems:

projection Offsets in the "radio" projection (see above).

trueHorizon "true angle horizon" offsets in Azimuth and Elevation:

$$\Delta a = (a - a_{source}) * \cos(e)$$

$$\Delta e = e - e_{source}$$

where a and e are the Azimuth and Elevation of the telescope; a_{source} and e_{source} are the Azimuth and Elevation of the source, calculated from l and b (and the time and other parameters).

Nasmyth offsets in the Nasmyth (receiver cabin) system. The purpose of Nasmyth offsets is exclusively to re-position the telescope so that an off-center element of a multibeam receiver looks at the position where otherwise the center pixel would look. E. g., `OFFSETS -33 44 /SYSTEM Nasmyth` adds offsets -33 and 44 in the Nasmyth system (for all observing modes!)

Example 1 Observe a single position with offsets 10 and 20 in system radio projection; typically used with Frequency Switching:

```
TRACK 10 20 /SYSTEM projection
```

Example 2 Observe `ONOFF` ("position switching" with Total Power) with ON position at 30 40 and off-source reference at -600 -700, both in system radio projection:

```
ONOFF 30 40 /REFERENCE -600 -700 projection /SYSTEM projection
```

Example 3 Pointing with subscans of length 120:

```
POINTING 120
```

Notes. For POINTING, the OTF offsets are always in system trueHorizon, and are specified implicitly though the angular length of the subscans.

Example 4 ONOFF observations with Wobbler Switching are a special case, because the offsets for the subscans must be in system trueHorizon and their values must be selected according to the offsets of the Wobbler Switching! E. g.,

```
SWWOBBLER -33 +33
ONOFF 33 0 /REFERENCE -33 0 trueHorizon /SYSTEM trueHorizon
```

This can also be achieved simply by saying

```
SWWOBBLER -33
ONOFF
```

PAKO "knows" the special requirements for onoff wobbler switching, and will set the offset parameters for `ONOFF` accordingly, if `SWWOBBLER` has been previously selected. [3]

In this special case, in order to map the source, the observer may add offsets on the source l and b using the command OFFSETS with the system "projection", *e.g.*:

```
SWWOBBLER -33
OFFSETS 110 120 /SYSTEM projection
ONOFF
```

NOTES. *`SOURCE` does not clear offsets set with `OFFSETS`.*

NOTES. If you are unsure about any of this, read the additional information in Section 6.1, or ask an astronomer whi is familiar with the NCS. For the time being, it is recommended not to try "fancy" combinations of offsets, which probably have not yet been fully tested and debugged.

2.13 Receiver Setup and Calibration Parameters

All parameters and options related to the setup of receivers and their calibration are specified with the command `RECEIVER`. This includes ambient and cold load temperatures, image sideband ratio, forward and main beam efficiencies, calibration scale antenna or (main) beam, and the HERA derotator.

2.14 Backends

Backend setup for all backends is done with the command `BACKEND`.

2.15 Continuous Data Acquisition and Data Streams

In the NCS, normally the data acquisition is continuous: fast independent data streams are generated by the backends as well as other subsystems, e.g., by the atenna mount drive to describe the antenna's movements. The data processing software synchronizes the data from different streams based on time stamps in the data. Most data streams keep continuously running even between subscans.

2.16 Display of Parameters

Most parameters set by the observer are displayed by a separate program, `pakoDisplay`, in another window, see Figure 2.

Several instances of this program can run at the same time, including on different screens, "desktops", and Linux machines.

2.17 Preview Plots

Commands for some observing modes, e.g., otfmap, automatically generate "preview" plots, see Figure 3.

The range of mapping offsets for these plots can be set with the usual GREG command limits, e.g., enter at the prompt `PAKO >` :

[3] For special purposes, it is possible to overrule this with `/swWobbler no`, *e.g.*, `ONOFF 44 /swWobbler no`.

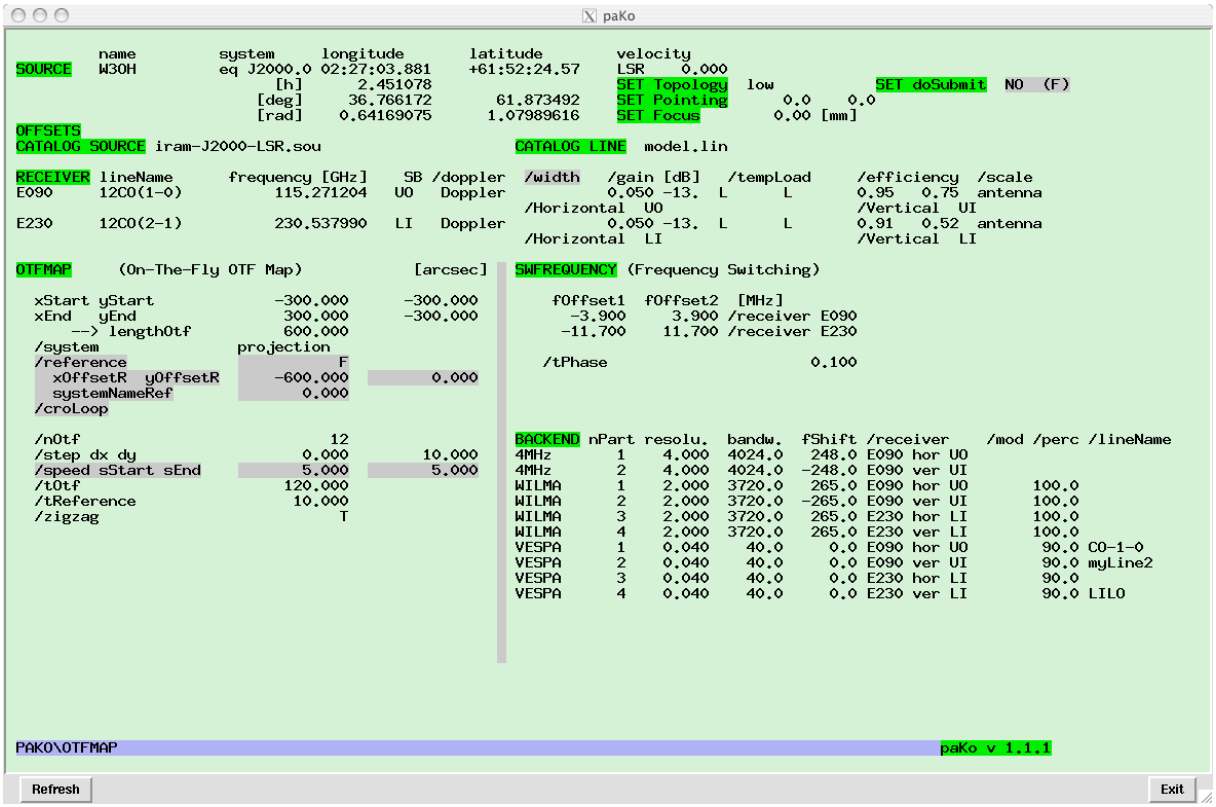

Figure 2: Screen shot of the PAKO Display.

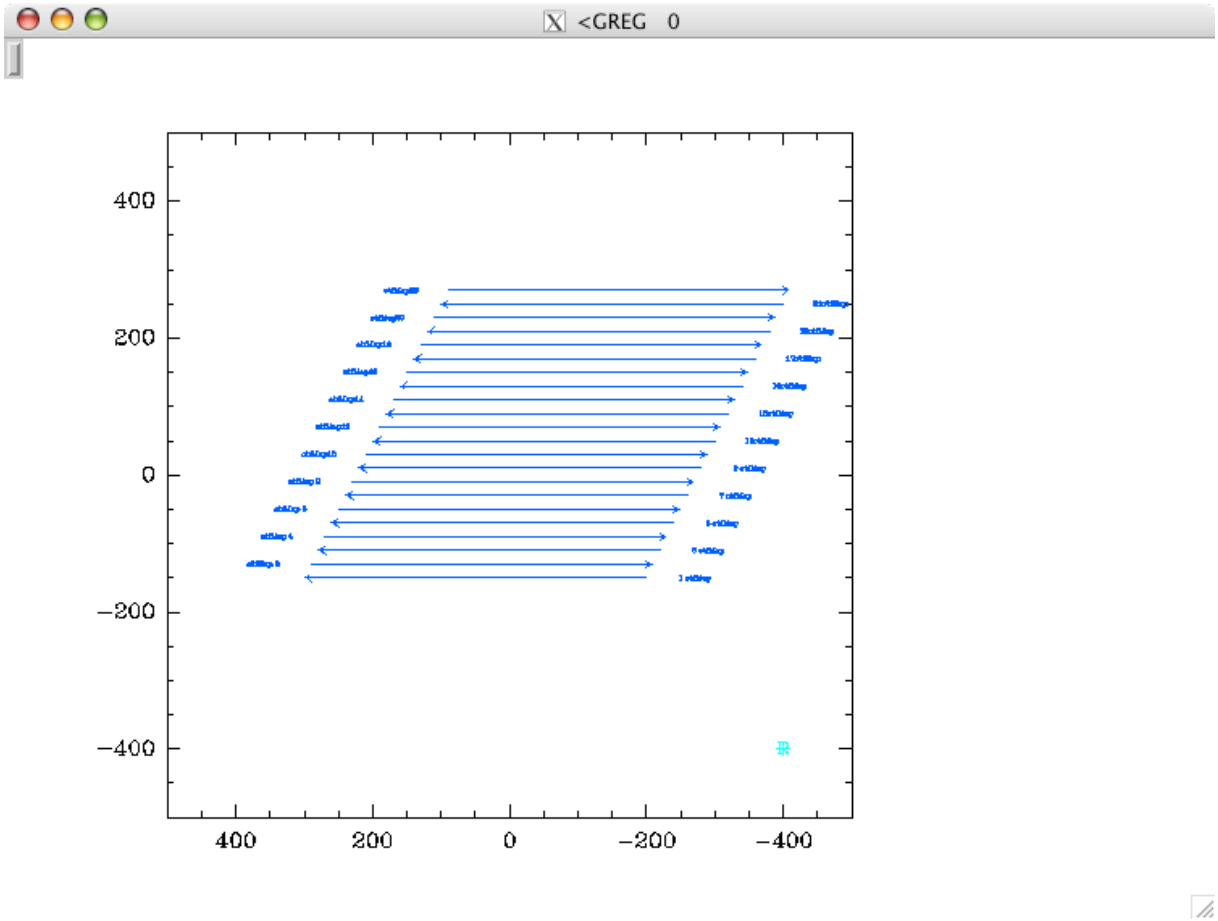

Figure 3: Screen shot of the PAKO preview plot.

```
DEVICE IMAGE W
LIMITS 500 -500 -500 500
SET BOX MATCH
BOX
```

Similarly, you can use other commands from GREG to change the color of the plotting "pens" or background of the window.

2.18 Defaults

Most commands have an option `/DEFAULT` which will set all options and parameters to meaningful default values. You can combine this option with explicit values for some parameters and options, e.g., enter at the prompt `PAKO >` :

```
OTFMAP /DEF /NOTF 12
```

means: default values for `OTFMAP`, but 12 OTF subscans.

2.19 Ranges and checks

Most parameters are checked to be within 2 ranges:

1. limits of allowed values. If you try to enter a value outside that range, you get an error message and the value is not accepted, e.g., enter at the prompt `PAKO >` :

```
POINTING /TOTF 4000
E-TOTF        /,  value 4000.000 outside limits 1.000000 to 3600.000
```

2. standard range. If you enter a value outside the standard range, you get a warning message, but the value is accepted, e.g., enter at the prompt `PAKO >` :

```
POINTING /TOTF 3000
W-TOTF        /,  value 3000.000 outside standard range 10.00000 to 600.0000
```

2.20 Independence of Command Parameters

The parameters of each observing mode are independent from the parameters of other observing modes. The same is true fop the different switching modes. For example, if you first enter at the prompt `PAKO >` :

```
OTFMAP /NOTF 12
```

and later:

```
POINTING /NOTF 4
```

the number of OTF subscans for OTFMAP is still at 12, as you can see with:

```
OTFMAP
```

Some options exist for several observing modes. E.g., options `/NOTF`, and `/TOTF` exist for POINTING and OTFMAP. The syntax, parameters and meaning of these options is then (almost) the same for all observing modes.

2.21 Option keywords

Options that start with:
`/t...` refer to times (durations), e.g., `/tOtf` = time per OTF subscan;
`/n...` refer to number of something, e.g., `/nOtf` = number of OTF subscans;
`/f...` refer to frequency of something;
`/temp...` refer to temperature of something.

2.22 Logical (YES/NO or ON/OFF) Options

Several options of commands are "logicals" which can have only one of 2 values: TRUE = YES, shown in the display as: T, or: FALSE = NO, shown in the display as: F. The command syntax and logic for ALL these options is the same, e.g., enter at the prompt `PAKO >` :

```
OTFMAP /ZIGZAG          ! TURN OPTION  ON/TRUE/YES : T
OTFMAP /ZIGZAG YES      ! TURN OPTION  ON/TRUE/YES : T
OTFMAP /ZIGZAG .TRUE.   ! TURN OPTION  ON/TRUE/YES : T
OTFMAP /ZIGZAG NO       ! TURN OPTION OFF/FALSE/NO : F
OTFMAP /ZIGZAG .FALSE.  ! TURN OPTION OFF/FALSE/NO : F
```

[Note: the default value for some logical options, e.g., `/ZIGZAG`, is T; for other logical options the default is F.]

2.23 Example Scripts and Catalogs

Examples of PAKO scripts, source and line catalogs are available on the WWW and in each project account.

3 PaKo's simplest recipe

This section gives a very short and simple overview of the steps needed to start spectral line observations. Details and more explanations are in the following sections, also in user's guides for special topics.

The following simple example is for both polarizations of one sub band, LI or UO, of one band, E090, of the EMIR receiver, see the EMIR user's guide for more information.

- Prepare a source catalog file, e.g., my.sou, with one line for each source that looks like:

```
W3OH EQ 2000 02:27:03.8812 +61:52:24.572 LSR -45.000
```

- Prepare a line catalog file, e.g., my.lin, with one text line for each line frequency like:

```
CS(2-1)         97.980968       LI
12CO(1-0)       115.271204      UO
```

  `LI` and `LO` refer to sub bands of the EMIR E090 band. See the EMIR user's guide for details.

- Start up PAKO (see local information how to do this).

- Enter some general options and information.

```
SIC PRIORITY 1 PAKO                 ! PAKO commands get precedence
SET LEVEL   0   0                   ! to get verbose chatter from pako
SET Project 111-22                  ! project ID (project number)
SET PI       "Dr. Lilo D. Doe"      ! principal investigator
SET Observer "John Doe"             !
SET Operator  Pako                  !
SET Topology  low                   ! topology for azimuth
SET doSubmit  YES                   ! allow submission to Queue
SHOW                                ! show parameters set with set
```

- Specify the line catalog and the receiver setup.

```
CATALOG  line my.lin                ! specify (your) line catalog
RECEIVER /CLEAR                     ! clear any previous RX setup
RECEIVER E090 12CO(1-0) /Horizontal /Vertical
```

  The options `/Horizontal /Vertical` mean that both polarizations will be used.

- Select your target source from your catalog; select a backend and do a calibration without sky to send the receiver setup.

```
CATALOG SOURCE my.sou               !  select your source catalog
SOURCE  W3OH                        !  source W3OH from your catalog
BACKEND /CLEAR                      !  clear any previous Backend setup
BACKEND WILMA /default              !  simple spectrometer setup for EMIR
BACKEND 4MHz  /default              !  simple spectrometer setup for EMIR
CALIBRATE /SKY NO                   !  doesn't need to move to sky position
START                               !  start
```

- Let the operator tune the reciver(s)
- Do a full calibration on the source, with default parameters:

```
CALIBRATE  /DEFAULT                 !  default calibration
START                               !  start
```

- Look at the results and check with the operator if the receiver noise temperature is OK.
- Select a strong compact continuum source for pointing and focussing; if possible, choose a source that is smaller than your beam!

```
SOURCE  2251+158 /catalog iram-J2000.sou ! pointing source from catalog
SOURCE  Uranus                           ! OR: a ‘‘small’’ planet
```

- Select the continuum backend for pointing and focus.

```
BACKEND  /CLEAR
BACKEND  BBC  /Default
```

`BACKEND BBC /Default` connects one part of the continuuum backend BBC to each polarization and sideband of each selected EMIR band.

- Select beam switching mode and do a pointing.

```
SWBEAM                              !  to select beam switching
POINTING /default                   !  pointing
START                               !  start
```

- After a pointing the data processing software displays the results and you can enter a correction for the observed pointing offsets with the command. Let's say, the results are $+3.4$ and -1.2 [arc sec]

```
SET POINTING 3.4 -1.2
```

- Do a focus measurement.

```
FOCUS            2.0                !  length [mm]
START                               !  start
```

- After a focus the data processing software displays the results and you can enter a new focus correction, e.g., -2.1 mm, with the command:

```
SET FOCUS -2.1
```

- Select a pointing source that is near your target source and do another pointing measurement and enter the resulting correction.
- Select the target source from your catalog; select a backend and do a calibration.

```
SOURCE  W3OH                        !  source W3OH from your catalog
BACKEND /CLEAR                      !  clear any previous Backend setup
BACKEND WILMA /default              !  simple spectrometer setup for EMIR
BACKEND 4MHz  /default              !  simple spectrometer setup for EMIR
CALIBRATE     /DEFAULT              !  default calibration
START                               !  start
```

`BACKEND WILMA /Default` connects one part of the WILMA spectrometer to each EMIR sub band selected with `RECEIVER`. `BACKEND 4MHz /Default` connects one part of the WILMA spectrometer to 2 EMIR sub bands selected with `RECEIVER`. [4]

- Select your switching and observing mode, e.g., wobbler switching and on-off, and start observing.

```
SWWOBBLER -120.0 120.0 /TPHASE 2.0          !  wobbler -/+ 120 arc sec
                                            !  2 seconds per phase
ONOFF /NSUBSCANS 12 /SYMMETRIC /TSUBSCAN 30 !  12 subscans
                                            !  "symmetric" subscan sequence
                                            !  30 sec per subscans
START
```

- Do a calibration at least every 15 minutes, or when you change sources, or when you change receiver and backend setups.
- Do a pointing every 2 hours or when you change to a different region of the sky.
- Do a focus every 6 hours and after sunset and sunrise.
  (Before focus, do a pointing on the focus source!)
- HAVE FUN!

  NOTES.

  PAKO has built-in help for all commands, e. g.,

```
HELP SWWOBBLER
HELP ONOFF /NSUBSCANS
```

Most commands can be abbreviated substantially, e. g., the following 2 are equivalent:

```
ON /NS 16 /SYM /TS 22
ONOFF /NSUBSCANS 16 /SYMMETRIC /TSUBSCAN 22
```

If you find that you enter the same command(s) very often, it is not necessary to type them every time! They can be put into command "scripts" either by editing a file or with PAKO's `SAVE` command, see section 2.

[4] Other spectrometers, e.g., VESPA, offer much more flexibility, but also need more parameters and more explicit `BACKEND` commands, see the following sections.

4 PaKo's Cook Book

This section provides a basic step-by-step cook book for doing standard observations in an interactive session with the telescope. It only gives simple examples, details on all the options that are available can be found in later sections.

It starts with some general commands and the selection of a source catalog. Then two more subsections explain how to do "Spectral Line Observations with Heterodyne Receivers" and "Continuum Observations with Bolometers".

Remember that in command language scripts based on SIC:

`!` starts a comment; `-` indicates that a command is continued on the next line; `PAUSE` pauses the execution of the script, e.g., in order to allow the user to review the parameters set; and the case (upper or lower) generally doesn't matter.

4.1 Set General Information

At the prompt `PAKO >` enter, e.g.:

```
SET PROJECT   111-22                        ! project ID (project number)
SET PI       "Dr. Jane D. Doe"              ! principal investigator
SET OBSERVER "John Doe"                     !
SET OPERATOR  Pako                          !
SET TOPOLOGY  low                           ! topology for azimuth
SHOW
DEVICE image  w                             ! open window for plots
```

With the `set` commands we specify some basic information: the project number, the principal investigator (PI), the names of the observer and telescope operator.

`SHOW` lists everything previously set with `SET`.

`SET TOPOLOGY` deserves special attention: The 30m antenna has azimuth limits of 60 and 460 degrees. Azimuth 360 degrees is due North. Therefore there is an overlap range approximately toward Northeast, which the antenna can reach at a low azimuth 60 to 100 (from the South) or at a high azimuth 400 to 460 (from the North).

`SET TOPOLOGY LOW` selects to use the azimuth range 60 to 420 degrees

`SET TOPOLOGY HIGH` selects to use the azimuth range 100 to 460 degrees.

`DEVICE` is a standard command to open a graphics window for plots. It is used by PAKO to provide a preview plot for some observing modes.

4.2 Specify your Source Catalog

At the prompt `PAKO >` enter, e.g.:

```
CATALOG SOURCE demo.sou
```

With this command we select the "source catalog", a special file, in which information about the sources is stored. A typical example of a source catalog looks like:

```
!
NameEq1 EQ 2000.0 02:23:16.50 61:38:57.0 LSR -45.0 FLUX 3.73 1.00
NameEq2 EQ 1950.0 02:23:16.50 61:38:57.0 LSR -45.0 FLUX 3.73 1.00
```

```
!
NameGa1 GA        03:23:16.50 63:38:57.0 LSR -33.0 FLUX 3.33 -0.33
NameGa2 GA        123.45      67.89      NUL -33.0 FLUX 3.33
!
```

An example of the source catalog can be found in file `demo.sou`.

Note that this format is like the format that can be used directly with the `SOURCE` (see `HELP SOURCE`) and also like the source catalog format used at PLATEAU DE BURE.

4.3 Spectral Line Observations with Heterodyne Receivers

4.3.1 Specify your Line Catalog

4.3.2 Setup of the Receivers (Frontends)

At the prompt `PAKO >` enter, e.g.:

```
RECEIVER A100                                ! defaults for all parameters
RECEIVER B100 12CO(1-0)                      ! using line catalog
RECEIVER A230 12CO(2-1) 230.537990 LSB       ! basic parameters explicit
```

Normally we use the `RECEIVER` command with 2 parameters: a receiver name and a line name. The line name must be the name of a line in the line catalog selected earlier.

Alternatively the frequency and sideband can be specified directly as the 3rd an 4th parameter.

One `RECEIVER` command is need for each receiver.

After all receivers are set up, and a source has been selected, the telescope operator or receiver engineer will tune the receivers. After tuning, he can tell you for each receiver: the ambient and cold load temperatures needed for the calibration, as well as the image band gain ratio.

These values describe physical parameters of the system that are not directly controlled, but which are important for the calibration of the data during data processing.

You can set these values with options of `RECEIVER`.

```
RECEIVER B100 12CO(1-0) 115.271204 LSB -    ! all parameters explicit
              /doppler fixed           -    ! fixed: no Doppler correction
              /gain 0.002              -    ! image sideband gain
              /tempLoad 88 277         -    ! cold and ambient load temperatures
              /efficiency 0.96 0.77    -    ! forward and (main) beam efficiencies
              /scale beam                   ! scale (main) beam brightness temperature
RECEIVER B230 /gain -22 db                  ! image sideband gain in [dB]
```

Note that with the syntax `/GAIN -22 db` you can specify the image gain directly in [dB].

Option `/EFFICIENCY` allows to specify values for the forward and (main) beam efficiencies.

Normally the system will provide reasonable defaults for all these calibation parameters.

Option `/SCALE` allows to choose the calibration scale: `ANTENNA` temperature or (main) `BEAM` brightness temperature.

4.3.3 Setup of the Backends (Spectrometers and Continuum)

At the prompt `PAKO >` enter, e.g.:

```
!
BACKEND CONTINUUM 1                 /r A100 ! continuum backend
BACKEND CONTINUUM 2                 /r B100
BACKEND CONTINUUM 3                 /r A230
BACKEND CONTINUUM 4                 /r B230
!
BACKEND 4MHz   1   4     1024    0  /r A230 ! 4MHz filters full syntax
BACKEND 4MHz   2                    /r B230 ! 4MHz filters short syntax
!
BACKEND 1MHz   1   1      512    0  /r A230 ! 1MHz filters full syntax
BACKEND 1MHz   2          256       /r B230 ! 1MHz filters short syntax
!
BACKEND 100kHz 1   0.1     12.8  0  /r A100 ! 100kHz filters full syntax
BACKEND 100kHz 2           12.8     /r B100 ! 100kHz filters short syntax
!
BACKEND WILMA  1   2     1024    0  /r A100 ! WILMA setup full syntax
BACKEND WILMA  2                    /r B100 ! WILMA setup short syntax
!
BACKEND VESPA  1   0.020   40.0  2  /r A100 ! standard VESPA setup
BACKEND VESPA  2   0.020   40.0  2  /r B100 !
BACKEND VESPA  3   0.040   80.0 -2  /r A230 !
BACKEND VESPA  4   0.040   80.0 -2  /r B230 !
!
```

Normally the command `BACKEND` has 5 parameters: backend name, part number, resolution [MHz], bandwidth [MHz], and frequency shift [MHz]. Option `/RECEIVER` connects this backend part to a receiver. This receiver must have been previously specified with `RECEIVER`.

For some backends the resulution, bandwidth, and/or frequency shift are fixed and a shorter syntax is possible, see, e.g., the example above for the continuum backends. See the `HELP` for complete information.

`/DISCONNECT` disconnects a backend (part) while retaining its parameters.

`/CONNECT` (re-)connects the sepcfied backend (part).

Normally the continuum backends are used for pointing and focus.

4.3.4 Calibration

4.3.5 Pointing

For pointing, you normally select first a pointing source and the continuum backends as described above.

At the prompt `PAKO >` enter, e.g.:

```
POINTING      60                          ! pointing with subscan length 80
START                                     ! start
```

After a pointing the data processing software displays the results and you can enter a correction for the observed pointing offsets with the command

`SET POINTING azimuthCorrection elevationCorrection`

4.3.6 Focus

4.3.7 Observing Modes for Line Spectroscopy

4.4 Continuum Observations with Bolometers

4.4.1 Setup of the Bolometer

4.4.2 Pointing

4.4.3 Focus

4.4.4 Tip ("Skydip")

4.4.5 Calibration

4.4.6 Observing Modes for the Bolometer

5 NCS User's Guide

This section contains an extended guide about how to setup and execute observations. The examples are in the form of valid scripts in the command language. These example scripts are available to each observer who can edit them according to their needs. Comment out (or delete) those lines of the scripts that don't apply for your observations.

It starts with some general commands and the selection of a source catalog. Then two more subsections explain how to do "Spectral Line Observations with Heterodyne Receivers" and "Continuum Observations with Bolometers".

Remember that in command language scripts based on SIC:

`!` starts a comment; `-` indicates that a command is continued on the next line; `PAUSE` pauses the execution of the script, e.g., in order to allow the user to review the parameters set; and the case (upper or lower) generally doesn't matter.

5.0.1 Set General Information

```
!
! $Id$
!
symbol show "pako\show"                     ! abbreviations for show
symbol sho  "pako\show"
symbol sh   "pako\show"
!
symbol poi  "pako\pointing"                 ! abbreviations for pointing
symbol po   "pako\pointing"
symbol p    "pako\pointing"
!
!!  set Level     2 4
set Project   111-22                        ! project ID (project number)
set PI       "Dr. Jane D. Doe"              ! principal investigator
set Observer "John Doe"                     !
set Operator  Pako                          !
set angleUnit arcsec                        ! angle unit for observing modes
set Pointing  1.1 2.2                       ! pointing corrections
set Focus     -2.22                         ! focus correction
set Topology  low                           ! topology for azimuth
!
show                                        ! show the values set with set
!
device image  w                             ! open window for plots
!
```

To execute this script, simply enter:

```
@ demo-set
```

This first sets some practical abbreviations that avoid confusion with the similar commands in other "languages", e.g., in GREG.

With the `set` commands we specify some basic information: the project number, the principal investigator (PI), the names of the observer and telescope operator.

`SHOW` lists everything previously set with `SET`.

`SET TOPOLOGY` deserves special attention: The 30m antenna has azimuth limits of 60 and 460 degrees. Azimuth 360 degrees is due North. Therefore there is an overlap range approximately toward Northeast, which the antenna can reach at a low azimuth 60 to 100 (from the South) or at a high azimuth 400 to 460 (from the North).

`SET TOPOLOGY LOW` selects to use the azimuth range 60 to 420 degrees
`SET TOPOLOGY HIGH` selects to use the azimuth range 100 to 460 degrees.
`DEVICE` is a standard command to open a graphics window for plots. It is used by PAKO to provide a preview plot for some observing modes.

5.1 Specify your Source Catalog

At the prompt `PAKO >` enter, e.g.:

```
CATALOG SOURCE demo.sou
```

With this command we select the "source catalog", a special file, in which information about the sources is stored. A typical example of a source catalog looks like:

```
!
NameEq1 EQ 2000.0 02:23:16.50 61:38:57.0 LSR -45.0 FLUX 3.73 1.00
NameEq2 EQ 1950.0 02:23:16.50 61:38:57.0 LSR -45.0 FLUX 3.73 1.00
!
NameGa1 GA        03:23:16.50 63:38:57.0 LSR -33.0 FLUX 3.33 -0.33
NameGa2 GA        123.45      67.89      NUL -33.0 FLUX 3.33
!
```

An example of the source catalog can be found in file `demo.sou`.
Note that this format is like the format that can be used directly with the `SOURCE` (see `HELP SOURCE`) and also like the source catalog format used at PLATEAU DE BURE.

5.2 Spectral Line Observations with Heterodyne Receivers

5.2.1 Specify your Line Catalog

5.2.2 Setup of the Receivers (Frontends)

```
!
! $Id$
!
RECEIVER      /DISCONNECT                   ! disconnect all receivers previously set
RECEIVER A100                               ! defaults for all parameters
RECEIVER A230 12CO(2-1) 230.537990 LSB      ! basic parameters explicit
                                            ! defaults for other parameters
RECEIVER B100 12CO(1-0) 115.271204 LSB -    ! all parameters explicit
              /DOPPLER FIXED           -    ! fixed: no Doppler correction
              /GAIN 0.002              -    ! image sideband gain
              /TEMPLOAD 88 277         -    ! cold and ambient load temperatures
              /EFFICIENCY 0.96 0.77    -    ! forward and (main) beam efficiencies
              /SCALE BEAM                   ! scale (main) beam brightness temperature
RECEIVER B230 /GAIN -22 db                  ! image sideband gain in [dB]
!
PAUSE
!
RECEIVER      /DISCONNECT                   ! disconnect all receivers previously set
RECEIVER C150
RECEIVER C270
RECEIVER D150
RECEIVER D270
!
```

```
PAUSE
!
RECEIVER      /DISCONNECT                    ! disconnect all receivers previously set
RECEIVER HERA-ALL
!
PAUSE
!
RECEIVER HERA1
RECEIVER HERA2
!
```

To execute this script, simply enter:

```
@ demo-receivers
```

Normally we use the `RECEIVER` command with 2 parameters: a receiver name and a line name. The line name must be the name of a line in the line catalog selected earlier.

Alternatively the frequency and sideband can be specified directly as the 3rd an 4th parameter.

One `RECEIVER` command is need for each receiver.

After all receivers are set up, and a source has been selected, the telescope operator or receiver engineer will tune the receivers. After tuning, he can tell you for each receiver: the ambient and cold load temperatures needed for the calibration, as well as the image band gain ratio.

These values describe physical parameters of the system that are not directly controlled, but which are important for the calibration of the data during data processing.

You can set these values with options of `RECEIVER`. Note that with the syntax `/GAIN -22 db` you can specify the image gain directly in [dB].

Option `/EFFICIENCY` allows to specify values for the forward and (main) beam efficiencies.

Normally the system will provide reasonable defaults for all these calibation parameters.

Option `/SCALE` allows to choose the calibration scale: `ANTENNA` temperature or (main) `BEAM` brightness temperature.

5.2.3 Setup of the Backends (Spectrometers and Continuum)

```
!
! $Id$
!
BACKEND /CLEAR                              ! clear all backend definitions
!
!!      option /R is short for /RECEIVER
!!      name   # resolu bandw.fShift   RX
!!      ------ - ------ ----- ------   ----
!
BACKEND CONTIN 1 500      500    0  /R A100 ! continuum backend full syntax
BACKEND CONTIN 2 500      500    0  /R B100
BACKEND CONTIN 3                    /R A230 ! continuum backend short syntax
BACKEND CONTINUUM 4                 /R B230
!
BACKEND 4MHz   1   4     1024    0  /R A230 ! 4MHz filters full syntax
BACKEND 4MHz   2                    /R B230 ! 4MHz filters short syntax
!
BACKEND 1MHz   1   1      512    0  /R A230 ! 1MHz filters full syntax
BACKEND 1MHz   2          256       /R B230 ! 1MHz filters short syntax
!
BACKEND 100kHz 1   0.1     12.8  0  /R A100 ! 100kHz filters full syntax
BACKEND 100kHz 2           12.8     /R B100 ! 100kHz filters short syntax
```

```
!
BACKEND WILMA  1   2     1024    0  /R A100 ! WILMA setup full syntax
BACKEND WILMA  2                    /R B100 ! WILMA setup short syntax
!
BACKEND VESPA  1   0.020   40.0  2  /R A100 ! standard VESPA setup
BACKEND VESPA  2   0.020   40.0  2  /R B100 !
BACKEND VESPA  3   0.040   80.0 -2  /R A230 !
BACKEND VESPA  4   0.040   80.0 -2  /R B230 !
!
BACKEND VESPA  5   0.020   40.0  2 -        ! VESPA
                      /RECEIVER A100 B100 - ! with 2 receivers
                      /MODE POLARIZATION    ! in polarization mode
!
BACKEND VESPA  6   0.040   80.0 -2 -        ! VESPA
                      /RECEIVER A230 B230 - ! with 2 receivers
                      /MODE PARALLEL -      ! in paralell mode
                      /PERCENTAGE 91        ! non-standard precentage used
!
```

To execute this script, simply enter:

```
@ demo-backends
```

Normally the command `BACKEND` has 5 parameters: backend name, part number, resolution [MHz], bandwidth [MHz], and frequency shift [MHz]. Option `/RECEIVER` connects this backend part to a receiver. This receiver must have been previously specified with `RECEIVER`.

For some backends the resulution, bandwidth, and/or frequency shift are fixed and a shorter syntax is possible, see, e.g., the example above for the continuum backends. See the `HELP` for complete information.

`/DISCONNECT` disconnects a backend (part) while retaining its parameters.

`/CONNECT` (re-)connects the sepcfied backend (part).

Normally the continuum backends are used for pointing and focus.

5.2.4 Calibration

5.2.5 Pointing

```
!
! $Id$
!
BACKEND /DISCONNECT                         ! disconnect all backends
BACKEND  CONTINUUM                          ! connect continuum backend
!
SET ANGLEUNIT arcsec                        ! make sure angle unit is arc sec
!
POINTING      80   -                        ! pointing with subscan length 80
   /CALIBRATE      -                        ! do a standard calibration first
   /NOTF       4   -                        ! 4 OTF subscans
   /TOTF      40.0                          ! 40 seconds per OTF subscan
!
PAUSE "POINTING OK? [c/q]"                  ! a chance to check
!
START                                       ! start
!
RETURN
!
```

```
!! Comments:
!! We assume here that the setup for the continuum backend has already
!! been done earlier and that the pointing is to be done with the
!! continuum backends.  Then the backend commands above achieve that
!! (only) the continuum backends are connected for the pointing.
!!
```

To execute this script, simply enter:

```
@ demo-pointing
```

After a pointing the data processing software displays the results and you can enter a correction for the observed pointing offsets with the command

```
SET POINTING azimuthCorrection elevationCorrection
```

5.2.6 Focus

5.2.7 Observing Modes for Line Spectroscopy

5.3 Continuum Observations with Bolometers

5.3.1 Setup of the Bolometer

5.3.2 Pointing

5.3.3 Focus

5.3.4 Tip ("Skydip")

5.3.5 Calibration

5.3.6 Observing Modes for the Bolometer

6 NCS Explained

In this section we explain in more detail some general aspects of the NCS.

6.1 Coordinate Systems, Map Projections, and Position Offsets

The NCS will support a variety of astronomical coordinate systems and projections, as well as "descriptive" coordinate systems defined by the user. Up to now, 2013-10-17, only equatorial coordinates, J2000.0, are well tested and available for use.

Map Projections and Offsets. In general, a "map projection" describes the relation between 2 spherical coordinates, longitude l and latitude b, [5] on the celestial sphere, and 2 Cartesian coordinates x and y, which in radio astronomy and the NCS we often call "position offsets".

Up to now, 2013-10-17, only the **"radio"** projection is supported, for which:

$$x = (l - l_{source}) * \cos(b)$$

$$y = b - b_{source}$$

where l_{source} and b_{source} are the source coordinates specified with `SOURCE`. [6] Note that this is the same system of offsets as in "OBS" of the old control system.

If we want to observe several positions on the sky at or near the source position as specified with `SOURCE`, we often do this by requesting position offsets in the map projection. Also, the resulting data, *e.g.*, images, are usually stored and displayed as a function of x and y.

For most observations, parameters and options of the observing mode are sufficient to specify the position offsets:

- for `TRACK` and `VLBI` x and y are fixed during the complete scan;
- for `ONOFF` x and y change from subscan to subscan;
- for `OTFMAP` x and y change continuously or "on-the-fly" (OTF) during the OTF subscans.

The PAKO commands for most Observing Modes expect fixed offsets (or start- and end-offsets for `OTFMAP`) as parameters. These can be either in the radio projection, specified with the option:
`/SYSTEM projection`
or in the true angle horizon system (see below), specified with the option:
`/SYSTEM trueHorizon`

NOTES. For POINTING, the OTF offsets are always in system trueHorizon, and are specified implicitly though the angular length of the subscans.

Global Offsets. On the other hand, the command `OFFSETS` can be used to specify additional position offsets in other systems. These globally defined offsets stay fixed during a complete scan. *They are only needed in special cases,* e.g.*, the Nasmyth offsets or for ONOFF with wobbler switching*, see below.

At this time (2013-10-17), the command `OFFSETS` supports offsets in the following 3 systems:

projection Offsets in the "radio" projection (see above).

trueHorizon "true angle horizon" offsets in Azimuth and Elevation:

$$\Delta a = (a - a_{source}) * \cos(e)$$

$$\Delta e = e - e_{source}$$

where a and e are the Azimuth and Elevation of the telescope; a_{source} and e_{source} are the Azimuth and Elevation of the source, calculated from l and b (and the time and other parameters).

[5] In particular for equatorial coordinates, l corresponds to Right Ascension and b to Declination.

[6] For the equations all angles are assumed to be in radian.

Nasmyth offsets in the Nasmyth (receiver cabin) system. The purpose of Nasmyth offsets is exclusively to re-position the telescope so that an off-center element of a multibeam receiver looks at the position where otherwise the center pixel would look. E. g., `OFFSETS -33 44 /SYSTEM Nasmyth` adds offsets -33 and 44 in the Nasmyth system (for all observing modes!)

Example 1 Observe a single position with offsets 10 and 20 in system radio projection; typically used with Frequency Switching:

```
TRACK 10 20 /SYSTEM projection
```

Example 2 Observe `ONOFF` ("position switching" with Total Power) with ON position at 30 40 and off-source reference at −600 −700, both in system radio projection:

```
ONOFF 30 40 /REFERENCE -600 -700 projection /SYSTEM projection
```

Example 3 Pointing with subscans of length 120:

```
POINTING 120
```

Notes. For POINTING, the OTF offsets are always in system trueHorizon, and are specified implicitly though the angular length of the subscans.

Example 4 ONOFF observations with Wobbler Switching are a special case, because the offsets for the subscans must be in system trueHorizon and their values must be selected according to the offsets of the Wobbler Switching! E. g.,

```
SWWOBBLER -33 +33
ONOFF 33 0 /REFERENCE -33 0 trueHorizon /SYSTEM trueHorizon
```

This can also be achieved simply by saying

```
SWWOBBLER -33
ONOFF
```

paKo "knows" the special requirements for onoff wobbler switching, and will set the offset parameters for `ONOFF` accordingly, if `SWWOBBLER` has been previously selected. [7]

In this special case, in order to map the source, the observer may add offsets on the source l and b using the command OFFSETS with the system "projection", *e.g.*:

```
SWWOBBLER -33
OFFSETS 110 120 /SYSTEM projection
ONOFF
```

Example (i) Observe an OTF map with first OTF subscan from offsets −300 −300 to +300 −300, and off-source reference at −600 −700, all in system radio projection:

```
OTFMAP -300 -300 300 -300 /REFERENCE -600 -700 projection /SYSTEM projection
```

[7] For special purposes, it is possible to overrule this with `/swWobbler no`, *e.g.*, `ONOFF 44 /swWobbler no`.

Example (ii) Observe an OTF map with first OTF subscan from offsets −300 −300 to +300 −300, in system trueHorizon (and no off-source reference) This is typical for bolometer OTF maps:

```
OTFMAP -300 -300 300 -300 /REFERENCE no /SYSTEM trueHorizon
```

NOTES. Visiting observers have also used ONOFF in trueHorizon combined with OFFSETS ... /SYSTEM projection with TOTAL POWER, apparently with success.

NOTES.

- one should not specify offsets for the same system with the observing mode and OFFSETS (and there is not need to do this!).
  - If the observing mode uses `/SYSTEM projection`,
    `OFFSETS ...` `/SYSTEM projection` is ignored (not used).
  - If the observing mode uses `/SYSTEM trueHorizon`,
    `OFFSETS ...` `/SYSTEM trueHorizon` is ignored (not used).
- in the commands for the observing modes, the offsets for off-source reference positions must be in the same system as those of the on-source or OTF positions, i.e., /REFERENCE ... and /SYSTEM must select the same system (normally, PROJECTION).

Details at a technical level about these and more offsets can be found in the documentation of "NCS Antennna Mount Drive" by Alain Perrigouard.

NOTES. More explanations about coordinate systems, projections, and how to define descriptive coordinate sytems will be added as they become available for general use.

NOTES. *`SOURCE` does not clear offsets set with `OFFSETS`.*

6.2 Azimuth Topology

The 30m antenna has azimuth limits of 60 and 460 degrees. Azimuth 360 degrees is due North. Therefore there is an overlap range approximately toward East-Northeast, which the antenna can reach at a low azimuth 60 to 100 (from the South) or at a high azimuth 420 to 460 (from the North).

`SET TOPOLOGY LOW` selects to use the azimuth range 60 to 420 degrees.

`SET TOPOLOGY HIGH` selects to use the azimuth range 100 to 460 degrees.

Note that `SET TOPOLOGY` only has an effect for sources with an azimuth in the overlap range; when a source is in the azimuth range 100 to 420 degrees `SET TOPOLOGY` does not matter.

Compare Figure 4.

6.3 Switching Modes

In the NCS we distinguish the following 4 "Switching Modes":

TOTAL POWER
BEAM SWITCHING
WOBBLER SWITCHING
FREQUENCY SWITCHING (only with heterodyne receivers)

The corresponding commands are:

```
SWTOTAL
SWBEAM
SWWOBBLER
SWFREQUENCY
```

BEAM SWITCHING, WOBBLER SWITCHING, and FREQUENCY SWITCHING are realized by a system with hardware synchronization signals that allow a precise and fast switching *within* subscans.

TOTAL POWER simply means that none of the other 3 switching modes is active.

The system switches through a regular cycle with several (1, 2, or 4) switching phases.

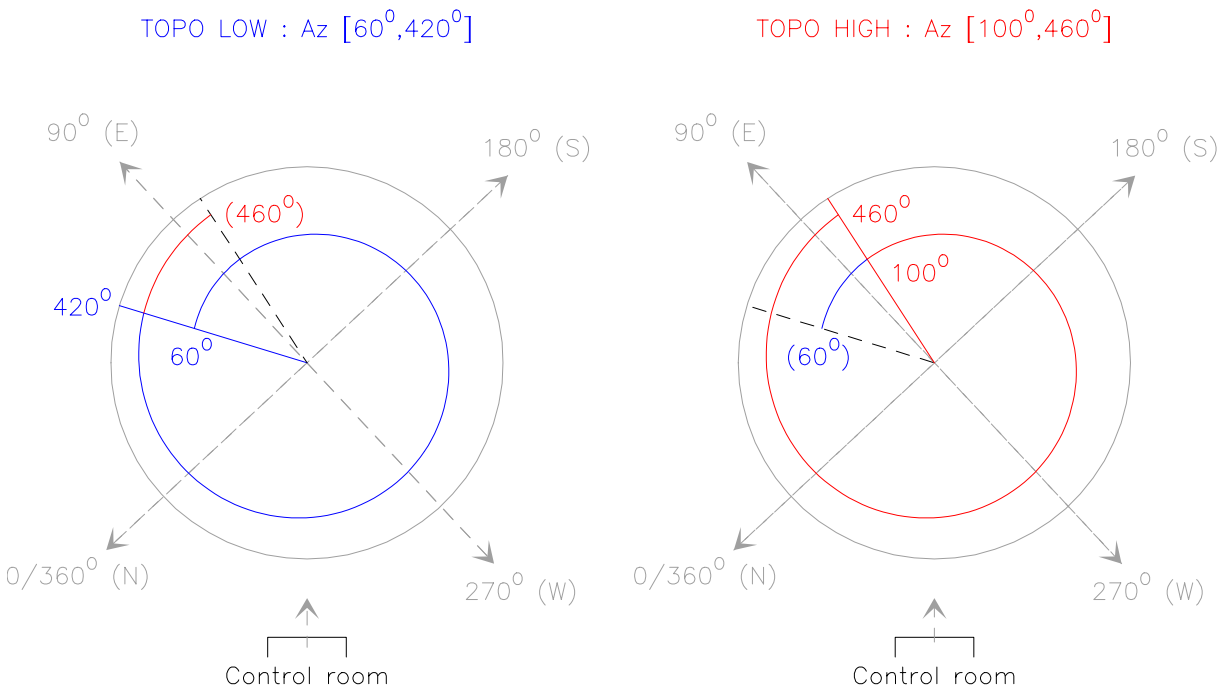

Figure 4: Azimuth Topology. The left side shows in blue the range for `SET TOPOLOGY LOW`, the right side shows in red the range for `SET TOPOLOGY HIGH`. (Compare Section 6.2; figure prepared by Joaquín Santiago)

The 4 switching modes are mutually exclusive, i.e., at any time the system uses only one of them.

During the transitions between phases, e.g., while the Wobbler is moving between its positions, no data are taken during the short "blanking" time.

The switching mode and its parameters should normally be set before choosing an observing mode, because for some observing modes details of the setup depend on the switching mode.

```
!
!  Id: demo-switching.pako,v 1.1.1 2009-05-05 Hans Ungerechts
!
SWTOTAL                        /tphase 0.2     !  Total Power
PAUSE
!
SWBEAM                                         !  Beam Switching
PAUSE
!
SWFREQUENCY                    /default        !  Frequency Switching
PAUSE
!
SWFREQUENCY   -3.3     3.3                     !  for all RXs
PAUSE
!
SWFREQUENCY   -3.9     3.9  /receiver E090     !  select frequency switching
SWFREQUENCY  -11.7    11.7  /receiver E230     !  for EMIR band E230
SWFREQUENCY                 /tphase   0.20     !  same for all receivers
PAUSE
!
SWWOBBLER   -22  +22          /tphase 0.25     !  Wobbler Switching
```

```
PAUSE
!
!! NOTE:
!! after changing the switching modes, always (re-)execute a command
!! for an observing mode, because internal parameters and error checks
!! of the observing modes depend on the switching mode!
```

6.3.1 Beam Switching

Beam Switching is realized through a rotating chopper wheel in the receiver cabin, which during each rotatation (= switching cycle) moves 2 reflecting (!) blades into the beam path in front of the 4th mirror, for a total of 4 phases: direct beam path to the source (same as in Total Power!), beam path offset by one blade of the chopper wheel, direct beam path to the source (same as in Total Power!), beam path offset by the other blade of the chopper wheel. The offset, rotation period, and blanking times are fixed. Beam Switching is normally only used for `POINTING` and `FOCUS`.

The source signal is calculated as difference between the direct and offset phases.

(Notes. This "beam-switching" chopper wheel, should not be confused with a "calibration chopper wheel" as it is used at some other mm-wave observatories. Calibration at the 30-m Telescope is done with different hardware.)

6.3.2 Frequency Switching

Frequency Switching switches between 2 different frequencies, so that there are 2 phases. The (source) signal is calculated as the difference between these 2 phases.

Frequency Switching is normally used with `TRACK` or `OTFMAP`.

Notes. IMPORTANT:

Frequency Switching *is very powerful and efficient for some projects, e. g., mapping of narrow spectral lines in cold dark clouds outside the plane of the Milky Way. However, before deciding to use frequency switching one should consider some potential drawbacks:*

The target lines should be narrow enough so that line signals from the 2 phases of the switching cycle are well separated.

The spectral baseline will generally be less flat than in other switching modes.

Some spectral lines are also emitted in the earth's mesosphere, e.g., the mesopheric lines from (12)CO are rather strong, and they will be seen in Frequency Switching *spectra taken toward astronomical sources with a low Doppler shift. The mesospheric lines will appear at a frequency and velocity that corresponds to the rest frame of the athmosphere, i. e., the observatory. Care must be taken that they are not confused with the lines from the astronomical source. (Information computed by the ASTRO software can help with this decision).*

When observing sources near the plane of the Milky Way, line emission from clouds at other velocities than the target source, e. g., other spiral arms, can cause confusion.

In case of doubt, consult the special memo on Frequency Switching *or ask an experienced* Frequency Switching *observer!*

6.3.3 Wobbler Switching

During Wobbler Switching the wobbling secondary mirror is switched between 2 positions, which are offset from the telescope axis by ± a fixed amount.

Thus there are 2 phases, and the signal is calculated as the difference between these 2 phases.

As the positions in both phases are offset from the telescope axis, in some observing modes, e.g, `POINTING`, `FOCUS`, `ONOFF`, the telescope position needs to be adjusted to compensate — this is done automatically.

Wobbler Switching is normally used with `ONOFF` or, for bolometer continuum mapping, with `OTFMAP`.

Note that for `OTFMAP` with Wobbler Switching, special restoration algorithms are needed to recover an image of the source brightness distribution. These are available, e. g., in the MOPSIC software.

If Wobbler Switching and `ONOFF` are combined in the standard way, we effectively take data at 3 positions: 1. the source position; 2. the `source position + throw` (offset in the "true-angle" horizontal system); 3. the `source position - throw` (offset in the "true-angle" horizontal system), with `throw = ABS(wOffset2-wOffset1)`. Data from 1. are treated as source signal, data from 2. and 3. as off-source reference signal. Note that in the astronomical coordinates, positions 2. and 3. will rotate around the source position 1. Therefore one must normally be sure that the extent of the source is less than `throw-beamWidth (/2)`.

6.3.4 Total Power

Total Power refers simply to data acquistion without any of the other 3 fast Switching Modes. (Even in this case the same type of hardware synchronization signals is used to control the regular readout of the backends. In this case there is only one switching phase.)

Normally, when using Total Power one or several positions "ON" the source are observed alternating with one or several "OFF"-source reference positions, and the signal is calculated as the difference between "ON" and "OFF".

6.4 Observing Modes

The NCS supports the following "Observing Modes": `CALIBRATE`, `POINTING`, `FOCUS`, `TIP`, `ONOFF`, `OTFMAP`, `<<TBD:RASTER` not yet implemented `>>`, `TRACK`, `VLBI`.

All Observing Modes are realized by executing a sequence of 1 or more subscans. In most cases, the antenna moves between or during the subscans.

The observing modes are mutually exclusive, i.e., at any time the system executes only one of them.

Several Observing Modes can be combined with different Switching Modes, e.g., `OTFMAP` with Total Power, Wobbler Switching (for bolometer), or Frequency Switching. The Switching Mode should normally be specified before the Observing Mode.

6.4.1 CALIBRATE

In a standard calibration for heterodyne receivers, we observe 3 subscans, "SAC": on a Sky position, an Ambient temperature load (a.k.a., "hot" load), and a "Cold" load. Calibrations are always and automatically done in Total Power.

A calibration needs to be done for any heterodyne observation in order to get data with a calibrated intensity scale. It is normally done before the target observations. It must always be done after changing receiver and/or backend setups. It should also be done when changing sources and often enough to follow any variation of the athmosphere, about every 15 minutes.

After you enter a calibrate setup manually, we recommend to "save" it, optionally to a named file:
`SAVE CALIBRATE [/FILE calibrate-1]`

It can then at any later time be reloaded with `@ calibrate[-1]`, see `HELP SAVE`.

The special calibration subscans are done by switching the beam optics so that the receivers see a special calibration unit in the receiver cabin.

6.4.2 POINTING

`POINTING` observations are done to optimize the positioning of the telescope in Azimuth and Elevation. This is normally done by continuum observations of a cross scan in azimuth and elevation on a point source (or at least a small source) near the intended target source.

It is normally used with Beam Switching or Wobbler Switching; it is also possible with Total Power. (With the bolometer `POINTING` is done with Wobbler Switching).

A calibration is not needed for `POINTING`, if one is only interested in the pointing corrections, and not in the source intensity.

After a pointing the data processing software displays the results and you can enter a correction for the observed pointing offsets with the command

`SET POINTING azimuthCorrection elevationCorrection`

Note that this is the total correction, i.e., the previous correction plus the additional offset found with the `POINTING` observation.

After you enter a pointing setup manually, we recommend to "save" it, optionally to a named file:

`SAVE POINTING [/FILE pointing-1]`

It can then at any later time be reloaded with `@ pointing[-1]`, see `HELP SAVE`.

6.4.3 FOCUS

`FOCUS` measurements are done to optimize the position of the subreflector (secondary) along the telescope axis by maximizing the intensity of the radiation focussed into the receiver(s). It is best done on a strong point source, e.g., on a planet if or when its angular diameter is less than the beam width at the frequency to be observed. It is strongly recommended to do a `POINTING` on the same source before a `FOCUS`.

`FOCUS` is normally used with Beam Switching or Wobbler Switching. (With the bolometer `FOCUS` is done with Wobbler Switching).

A calibration is not needed for `FOCUS`, anyhow it will probably already have been done before the `POINTING` before the `FOCUS`!

After a focus the data processing software displays the results and you can enter a correction for the observed focus offset with the command

`SET FOCUS focusCorrection`

Note that this is the total correction, i.e., the previous correction plus the additional offset found with the `FOCUS` observation.

The optiomal focus correction for different receiver bands may be slightly different, by a few times 0.1 mm, and the observer can decide to optimize for one particular band or use a compromise value.

After you enter a focus setup manually, we recommend to "save" it, optionally to a named file:

`SAVE FOCUS [/FILE focus-1]`

It can then at any later time be reloaded with `@ focus[-1]`, see `HELP SAVE`.

6.4.4 TIP

`TIP` (antenna tipping or "skydip") observations are done to measure the transmission of the Earth's athmosphere, by taking data at several points with the same azimuth but different elevations, spaced by equal steps in "air mass".

It is ESSENTIAL that the switching mode is Total Power during `TIP`.

This is in particular an important step in the calibration of observations with the bolometer.

The basic parameters of this observing mode and its options are: the azimuth, the range and step in airmass, and the time per subscan.

6.4.5 ONOFF

In its first form `ONOFF` is used with Total Power. Subscans are taken alternating between a position that's considered to be "ON-source" and a reference position that's normally assumed to be "OFF-source", i.e., free of emission.

The source signal is then calculated as the difference between "ON" and "OFF".

The basic parameters are the offsets for the ON position, parameters of the options are the offsets for the reference position, the (total) number of subscans, and the time per subscan in [s].

After you enter an ON-OFF setup manually, we recommend to "save" it, optionally to a named file:

`SAVE ONOFF [/FILE onoff-1]`

It can then at any later time be reloaded with `@ onoff[-1]`, see `HELP SAVE`.

You may want to save the switching mode seperately or with ONOFF into the same file:

```
SAVE SWITCHING /FILE onoff-2
SAVE ONOFF     /FILE onoff-2 /APPEND
```

When ONOFF is used with Wobbler Switching (command SWWOBBLER), the position offsets must be set to very specific values in true (angle) horizon depending on the parameters of SWWOBBLER. This is achieved by using the special option /SWWOBBLER of the command ONOFF.

Subscans are then taken alternating between 2 positions in such a way that: (a) in some subscans (one position of the antenna) the source is in the first of the two Wobbler phases, (b) in the other subscans (the other position of the antenna) the source is in the second of the two Wobbler phases. During the data processing, the source signal is computed as a double difference: 1st the difference of the 2 Wobbler phases; 2nd the difference between ONOFF subscans (a) and (b).

This form of ONOFF is also called "Wobbler-Onoff" or sometimes simply "Wobbler Switching".

The combination(!) of ONOFF and Wobbler Switching provides a very high sensitivity in continuum bolometer observations of compact sources, and excellent baselines for spectroscopy.

It has the disadvantage that the (emission-free?) off-source positions are very close to the source (limited by the maximum Wobbler throw). Also, the Wobbler direction is fixed in the horizontal system relative to the telescope, and therefore in the source system the off-source positions rotate around the source position.

For continumm observations, usually a short time per Wobbler phase, 0.25 s, is used with small Wobbler offsets (throws); for spectroscopy, largest possible Wobbler offsets (throws), up to $\pm 120''$ are preferred, but then the time per phase must be longer, 1 – 2 s.

6.4.6 OTFMAP

In OTFMAP (on-the-fly) observations, the antenna moves relative to the source while recording its position and taking data a high rate, thus performing "scans" in the strict sense of the word. This is a very fast mode for mapping.

The basic parameters of the command are the position offsets of the start and end of the first OTF subscan; the basic parameters of the options are: the number of OTF subscans, the offsets of an off-source reference position, the step (shift) in x- and y-offsets between subsequent OTF subscans, the time per OTF subscan in [s], and the time per off-source reference subscan [s].

This observing mode is normally used either with:

(i) Total Power with an off-source reference for spectral line observations, or

(ii) Frequency Switching without off-source reference for spectral line observations (see below), or

(iii) Wobbler Switching and true (angle) horizon offsets for continuum mapping with the bolometer.

After you enter an OTF-map setup manually, we recommend to "save" it, optionally to a named file:
SAVE OTFMAP [/FILE otfmap-1]
It can then at any later time be reloaded with @ otfmap[-1], see HELP SAVE.
You may want to save the switching mode seperately or with OTFMAP into the same file:

```
SAVE SWITCHING /FILE otfmap-2
SAVE OTFMAP    /FILE otfmap-2 /APPEND
```

6.4.7 RASTER

<< RASTER (not yet implemented), will be similar to ONOFF and TRACK but allow to observe several "ON" positions. To be used with Total Power or (maybe) Frequency Switching. In any case it is recommended to use ONOFF instead of RASTER with several ON per OFF. >>

6.4.8 TRACK

The TRACK observing mode simply tracks one position relative to the source. It is normally used with Frequency Switching and offsets in /SYSTEM projection.

The basic parameters are the offsets for the position to track; parameters of the options are the (total) number of subscans, and the time per subscan in [s].

After you enter a track setup manually, we recommend to "save" it, optionally to a named file:
`SAVE TRACK [/FILE track-1]`
It can then at any later time be reloaded with `@ track[-1]`, see `HELP SAVE`.
You may want to save the switching mode seperately or with TRACK into the same file:

```
SAVE SWITCHING /FILE track-2
SAVE TRACK     /FILE track-2 /APPEND
```

6.4.9 VLBI

`VLBI`. a special observing mode to track the source position specified with `SOURCE` during VLBI scans. It should only be used for VLBI and is always used with TOTAL POWER.

6.5 Receivers

This section remains to be written. For the time being please refer to the information available on the web pages about the 30-M Telescope.

6.6 Backends

This section remains to be written. For the time being please refer to the information available on the web pages about the 30-M Telescope.

7 PAKO Language Internal Help

From here follows a reproduction of the Internal Help available in paKo with `HELP PAKO`. Please consult the internal help itself, which may be more up to date then an old printout of the user's manual.

NOTES.

`<<` and `<< TBD` mark items that are foreseen in the NCS but that are not yet available.

7.1 Language

```
NEW in v1.2.3 (2014-11-11)
==========================

LISSAJOUS /FOCUS     f1 f2 [... f18] [direction]    ! for NIKA
LISSAJOUS /POINTING                                 ! for NIKA
LISSAJOUS /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA

FOCUS     /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA
OTFMAP    /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA
POINTING  /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA

RECEIVER  BOLOMETER  NIKA         pixel             ! for NIKA




SUMMARY OF PAKO\ COMMANDS v1.2.3

Examples how to use HELP:

for detailed HELP on a command:  HELP OTFMAP
                                 HELP OTFM
one subtopic or option:          HELP OTFMAP /NOTF
examples:                        HELP OTFMAP EXAMPLES
all subtopics and options:       HELP OTFMAP *
options in general:              HELP OPTIONS
news about paKo:                 HELP PAKO\ NEWS


NOTE:  <<TBD     ... >>    (To BE DONE) or
       <<        ... >>    flag items that are planned for the NCS, but
                           not yet implemented or propely tested.
                           Observers should not try to use these features
                           without consulting the NCS team.

   setup:
SET & SHOW           set general parameters (project, observer, ...)
CATALOG              select source or line catalogs
SOURCE               specify a source
OFFSETS              specify source offsets
RECEIVER             set up receivers
BACKEND              set up backends

   switching modes (select 1)
SWBEAM               select and set up beam switching
```

```
SWFREQUENCY          select and set up frequency switching
SWTOTAL              select total power (no switching)
SWWOBBLER            select and set up wobbler switching

   observing modes (select 1)
CALIBRATE            specify a calibration
FOCUS                specify a focus measurement
POINTING             specify a pointing measurement
TIP                  specify an antenna tipping (a.k.a., "skydip")
TRACK                specify tracking of a single position, e.g., with SWFRE
ONOFF                specify on-off (a.k.a, "position switching")
OTFMAP               specify an On-The-Fly (OTF) map
LISSAJOUS            specify an On-The-Fly map along a Lissajous curve
VLBI                 specify tracking of a single position for VLBI

   start:
START                start an observation, i.e., send it to the queue

   save:
SAVE                 save parameters to file, i.e., a .pako script



NEW in v1.2.3 (2014-11-11)
==========================

LISSAJOUS /FOCUS     f1 f2 [... f18] [direction]    ! for NIKA
LISSAJOUS /POINTING                                 ! for NIKA
LISSAJOUS /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA

FOCUS     /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA
OTFMAP    /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA
POINTING  /TUNE      xOffsetT     yOffsetT          ! for NIKA
          /TTUNE     tTune                          ! for NIKA

RECEIVER  BOLOMETER  NIKA         pixel             ! for NIKA


NEW in v1.1.15:
==============

Support for the upgrade of EMIR band E150 to full 2*2*8 GHz LSB+USB
in both polarizations, and the E330 local oscillator to higher
frequencies (2013-09).

There are NO new commands in v1.1.15


NEW in 1.1.14:
==============
```

```
RECEIVER BOLOMETER NIKA          ! Receiver (bolometer) NIKA

SUBSCAN xOffset yOffset  /TUNE                    ! for NIKA
DIY                      /PURPOSE "play my Tune"  ! for NIKA


NEW in 1.1.12:
==============

RECEIVER BOLOMETER GISMO    ! Receiver (bolometer) GISMO

LISSAJOUS                   ! Observing Mode Lissajous for GISMO, i.e.,
                            ! an On-The-Fly map along a Lissajous curve


UPDATED in 1.1.11:
==================

RECEIVER EMIR               ! Receiver EMIR, upgrade of E230 and E330
BACKEND  FTS                ! Fourier Transform Spectrometer
BACKEND  BBC                ! Broad Band Continuum Backend

SET      EMIRcheck          ! limit checking for EMIR
SET      UserLevel          !


NEW in v1.1.5:
=============

BACKEND BBC                 ! Broad  Band Continuum Backend
BACKEND NBC                 ! Narrow Band Continuum Backend


NEW in v1.1.4:
=============

BACKEND FTS                 ! Fourier Transform Spectrometer
SET     EMIRCheck           ! "strict"|"relaxed"|"loose"


NEW in v1.1.1: SUPPORT FOR EMIR
===============================

--> major changes in

CALIBRATE
BACKEND
RECEIVER



-----
NOTE:  <<TBD ... >>    (To BE DONE) or
```

```
<<    ... >>    flag items that are planned for the NCS, but
                not yet implemented or properly tested.
                Observers should not try to use these features
                without consulting the NCS team.
```

7.2 BACKEND

```
BACKEND  name      nPart resolution bandwidth fShift
                       receiverBand [polarization subband|sideband]

BACKEND  /CLEAR

Alternative short syntax (only for the backends shown here!):
BACKEND  BBC   nPart           /REC receiverBand [polarization sideband]
BACKEND  NBC   nPart           /REC receiverBand [polarization subband]
BACKEND  4MHz  nPart           /REC receiverBand [polarization subband]
BACKEND  WILMA nPart           /REC receiverBand [polarization subband]
BACKEND  FTS   nPart           /REC receiverBand [polarization subband]
BACKEND  FTS   nPart /FINE     /REC receiverBand [polarization subband]

Set up backends for heterodyne receivers.

Character :: name           ! name of backend
Integer   :: nPart          ! (logical) number of backend part
Real      :: resolution     ! [MHz]
Real      :: bandwidth      ! [MHz]
Real      :: fShift         ! frequency shift [MHz]
Character :: receiverBand   ! receiver band      to connect to backend part
Character :: polarization   ! EMIR: polarization to connect to backend part
Character :: subband        ! EMIR: subband      to connect to backend part
Character :: sideband       ! EMIR: sideband     to connect to backend part

Choices for (backend) name are:
BBC                         ! Broad  Band Continuum Backend
NBC                         ! Narrow Band Continuum Backend
4MHz                        ! filter spectrometers with fixed resolution
WILMA                       ! autocorrelation spectrometers
FTS                         ! Fourier Transform Spectrometer
VESPA                       ! autocorrelator with variable resolution


Choices for receiverBand are (compare RECEIVER command):
E090 E150 E230 E330 HERA1 HERA2

Choices for polarization are (for EMIR; compare RECEIVER command):
Horizontal Vertical

Choices for subband   |   sideband, when observing with EMIR, are:
        LO LI UI UO   |   LSB USB
```

```
LSB and USB apply only to EMIR bands with 8 GHz bandwidth (E090, E230,
and E330) and Backend BBC.

fShift can be used to shift (offset) the backend band within the
receiver band; this only applies to some backends, in particular
VESPA. For VESPA, the range for fShift is much smaller than the 4GHz
subbands of EMIR. For wide-bandwidth backends, fShift is fixed,
corresponding to the frequency pattern of the EMIR subbands and
backend bands. See EMIR and backend documentation.

/CLEAR completely clears the backend setup.

If option /CLEAR is present, all other parameters and options are ignored.

NOTE: EMIR subbands, IF cables, and Backends

The output signals from EMIR are transmitted to the spectrometers and
NBC through 8 IF cables. Each IF cable carries one subband of bandwidth
4 GHz. This subbands are LO, LI, UI, or UO.

NBC, 4MHz, WILMA, and VESPA can only(!) be connected to IF cables 1 to 4.
FTS parts 1 to 4 can also be connected to IF cables 1 to 4.

The command options RECEIVER /HORIZONTAL and RECEIVER /VERTICAL allow
to select up to 4 EMIR subbands that will be transmitted through IF
cables 1 to 4 (compare HELP RECEIVER /HORIZONTAL and the EMIR user
documentation). This selection can include Outer subbands.

In addition, the IF cables 5 to 8 carry the 4 Outer subbands
corresponding to the subbands selected for IF cables 1 to 4. E.g., if
we select for IF 1 to 4:
E230 ver UO    E090 ver UI    E230 hor UI   E090 hor UI
then the IF cables 5 to 8 will transmit:
E230 ver UO    E090 ver UO    E230 hor UO   E090 hor UO.

Only FTS parts 5 to 8 can be connected to IF cables 5 to 8.

BACKEND NBC|WILMA|FTS /DEFAULT will automatically set the maximum
number of backend parts for all available subbands.

BACKEND BBC is completely independant of the sub band selections for
the IF cables.

NOTES:
- for some backends the resolution and/or bandwidth are fixed and the
  short syntax can be used. (The full syntax is supported for all backends).
- for VESPA always use the full syntax!
- after changing the receiver configuration: BACKEND /CLEAR is recommended
  followed by the backend setup for the new receivers; without that it is
  possible that pako will not accept BACKEND commands because of unresolved
  conflicts between the RECEIVER and BACKEND setups.
- However, the backend command will automatically try to disconnect
  backends that were connected to receiver (sub)bands that are not
  connected anymore.
```

7.2.1 BACKEND BBC

```
BBC                          ! Broad  Band Continuum Backend

BBC works only with the EMIR receiver.  One part of BBC always covers
the full 8 GHz bandwidth of each sideband of each polarization of each
EMIR band selected with the RECEIVER command.

Band  Sidebands      IF      Width  Polariz.  # BBC parts
                     [GHz]   [GHz]            -----------

E090  LSB and USB    4--12    8     H and V       4
E150  LSB and USB    4--12    8     H and V       4
E230  LSB and USB    4--12    8     H and V       4
E330  LSB and USB    4--12    8     H and V       4

Shortcut: after selecting EMIR bands and subbands, BACKEND BBC
/DEFAULT automatically sets all this appropriately!
```

7.2.2 BACKEND FTS

```
FTS                          ! Fourier Transform Spectrometer

The FTS supports two modes:
 -  wide bandwidth, up to ~ 4000 MHz on EMIR (~ 1000 MHz on HERA),
    with a resolution of ~ 0.195 [MHz], or
 -  fine resolution, ~ 0.049 MHz,
    with a bandwidth up to 1820 MHz on EMIR (~ 500 MHz on HERA)

All parts of the FTS must use the same resolution.

NOTE: EMIR subbands, IF cables, and Backends

The output signals from EMIR are transmitted to the spectrometers and
NBC through 8 IF cables. Each IF cable carries one subband of bandwidth
4 GHz. This subbands are LO, LI, UI, or UO.

NBC, 4MHz, WILMA, and VESPA can only(!) be connected to IF cables 1 to 4.
FTS parts 1 to 4 can also be connected to IF cables 1 to 4.

The command options RECEIVER /HORIZONTAL and RECEIVER /VERTICAL allow
to select up to 4 EMIR subbands that will be transmitted through IF
cables 1 to 4 (compare HELP RECEIVER /HORIZONTAL and the EMIR user
documentation). This selection can include Outer subbands.
```

```
In addition, the IF cables 5 to 8 carry the 4 Outer subbands
corresponding to the subbands selected for IF cables 1 to 4. E.g., if
we select for IF 1 to 4:
E230 ver UO    E090 ver UI    E230 hor UI   E090 hor UI
then the IF cables 5 to 8 will transmit:
E230 ver UO    E090 ver UO    E230 hor UO   E090 hor UO.

Only FTS parts 5 to 8 can be connected to IF cables 5 to 8.

BACKEND NBC|WILMA|FTS /DEFAULT will automatically set the maximum
number of backend parts for all available subbands.

BACKEND BBC is completely independant of the sub band selections for
the IF cables.


NOTE: bandwidth selection with EMIR

The pako command already allows some flexibility that is not yet fully
supported by the data handling, e.g., to select only part of the full
bandwidth.


NOTE: FTS on HERA

With HERA, the FTS can be connected to HERA1 and/or HERA2.

On HERA, the FTS provides some extra bandwidth, which is not
symmetrical to the point where the line (the commanded frequency) gets
centered.

With HERA /width wide, the line gets centered at the center of WILMA
and 4MHz.  Relative to this point, the FTS in wide mode covers IF
offset frequencies from < -512 to > +512. In pako the nominal value of
the bandwidth is 1024, symmetric around the line.

With HERA /width narrow, the line gets centered at the center of
VESPA.  Relative to this point, the FTS in fine mode covers IF offset
frequencies from < -256 to > +360. In pako the nominal value of the
bandwidth is 512, symmetric around the line.

It is also possible to connect FTS in fine mode on HERA /width wide or
FTS in wide mode on HERA /width narrow.  However, in these cases the
FTS band coverages are very asymmetric to the line. (See HERA and FTS
documentation for the exact details of the IF ranges).
```

7.2.3 BACKEND /DEFAULTS

```
/DEFAULTS  [yes|no]
```

```
Set default values.

If EMIR sub bands have been selected with the RECEIVER command,
this option has a special function for some Backends:

BACKEND BBC       /Defaults     connects one BBC  part to each
                                sideband (!) of each selected EMIR band
                                (up to 8)

BACKEND NBC       /Defaults     connects one NBC  part to each
                                selected EMIR sub band (up to 4)

BACKEND 4MHZ      /Defaults     connects one 4MHz part to each of
                                the 1st and 2nd selected EMIR sub band

BACKEND WILMA     /Defaults     connects one WILMA part to each
                                selected EMIR sub band (up to 4)

BACKEND FTS       /Defaults     connects one FTS part in "wide" bandwidth
                                to each EMIR sub band (up to 4) selected
                                for IF cables 1 to 4, and additionally
                                one part to each of the available Outer
                                subbands (up to 4) on IF cables 5 to 8

BACKEND FTS /Fine /Defaults     connects one FTS part in "fine" resolution
                                to each EMIR sub band (up to 4) selected
                                for IF cables 1 to 4, and additionally
                                one part to each of the available Outer
                                subbands (up to 4) on IF cables 5 to 8
```

7.2.4 BACKEND /CLEAR

```
/CLEAR  [yes|no]

Completely clear a list of connected hardware, e.g., receivers, backends,
or parameters of the associated command.


After changing the receiver configuration: BACKEND /CLEAR is recommended
followed by the backend setup for the new receivers; without that it is
possible that pako will not accept BACKEND commands because of unresolved
conflicts between the RECEIVER and BACKEND setups.
```

7.2.5 BACKEND /CONNECT

```
/CONNECT [yes|no]

connect (or disconnect) the specified hardware, e.g.,
backend or backend part.
```

```
--> DEPRECATED. PROTECTED (needs SET userLevel)
```

7.2.6 BACKEND /DISCONNECT

```
/DISCONNECT

disconnect the specified hardware, e.g.,
backend or backend part.

-->  DEPRECATED. PROTECTED (needs SET userLevel)
```

7.2.7 BACKEND /FINE

```
/FINE

for BACKEND FTS select the "fine" mode with a resolution of ~ 0.049 [MHz]

Note: with the option /DEFAULT or the short syntax, this allows to
select the fine resolution without explicitly entering the values of
resolution and bandwidth.
```

7.2.8 BACKEND /MODE

```
/MODE mode

Character :: mode                ! backend mode

Choices for mode are:
SIMPLE                           ! simple (standard)
PARALLEL                         ! parallel mode
POLARIZATION                     ! polarimetry

Select special mode for VESPA.
See VESPA user's guide for details.

For EMIR, /MODE PARALLEL or /MODE POLARIZATION connect VESPA
to the same band and subband in both polarizations; they must
previously have been selected with the RECEIVER command. For
exmples, see:
HELP BACKEND Examples
```

7.2.9 BACKEND /LINENAME

```
/LINENAME lineName

Character :: lineName          ! name of line. don't use @ < >

--> OPTION OF BACKEND COMMAND FOR USE WITH EMIR

This allows to set a "line" name for each backend part.

If a line name is set for a backend part, it will be used in the CLASS
header of the spectrum from that backend part.

If no line name is set for a backend part (default), the line name
from the corresponding RECEIVER band will be used in the CLASS header.

This is an optional convenience feature to make it easier to identify
spectra by appropriate names, in particular in cases where several
different lines are observed simultaneously with the same receiver
band.

This is only a name or label, and has no influence on any frequencies
or other control parameters.
```

7.2.10 BACKEND /PERCENTAGE

```
/PERCENTAGE percentage

Real :: percentage  !  percentage of bandwidth to use

This is a special option for the autocorrelators, VESPA and WILMA.

For autocorrelators normally some channels at both ends of the band
are blanked because they do not contain usable data, and only the
central 'percentage' of the "theoretical" bandwidth is used, typically
about 90%.  Reasonable conservative defaults are automatically
applied: in general 90%, but 82% for VESPA with bandwidth 640.  This
option allows the observer to adjust the percentage for special
purposes.

For WILMA connected to EMIR, the useful bandwidth is 3720 MHz,
and counted as 100%.

See VESPA user's guide for details.
```

7.2.11 BACKEND /RECEIVER

```
/RECEIVER receiverBand [polarization subband|sideband]

Character :: receiverBand   ! receiver band      to connect to backend part
Character :: polarization   ! EMIR: polarization to connect to backend part
```

```
Character :: subband        ! EMIR: subband      to connect to backend part
Character :: sideband       ! EMIR: sideband     to connect to backend part

Choices for receiverBand are (compare RECEIVER command):
E090 E150 E230 E330 HERA1 HERA2

Choices for polarization are (for EMIR; compare RECEIVER command):
Horizontal Vertical

Choices for subband   |   sideband, when observing with EMIR, are:
        LO LI UI UO   |   LSB USB
LSB and USB apply only to EMIR bands with 8 GHz bandwidth (E090, E230,
and E330) and Backend BBC.
```

7.2.12 BACKEND EXAMPLES

```
!
! Id: demo-backend.pako
!     basic BACKEND EXAMPLES,v 1.1.11 2011-11-24 Hans Ungerechts
!
swTotal /default                              ! select a switching mode
!                                             ! compatible with all backends
!
!   one example of a complex EMIR setup:
!
! pako\RECEIVER
pako\RECEIVER /clear
!
RECEIVER E090 CS(2-1) 97.980965 LI  -
 /horizontal  LI                    -
 /vertical    LI
!
RECEIVER E230 CO(2-1) 230.537994 LI -
 /horizontal  LI                    -
 /vertical    LI
!
!
BACKEND /CLEAR                                ! clear all backend setups
!
!                                             ! EMIR BBC
BACKEND BBC        /Default                   ! connect 1 part
!                                             ! to both polarizations
!                                             ! of each sideband
!                                             ! of each selected EMIR band
pause
!
!                                             ! EMIR NBC
backend /clear
BACKEND NBC        /Default                   ! connect 1 part to
!                                             ! each selected EMIR subband
pause
!
!                                             ! EMIR WILMA
```

```
backend /clear
BACKEND WILMA      /Default                    ! connect 1 part to
!                                              ! each selected EMIR subband
pause
!
!
!                                              ! EMIR 4MHz
!                                              ! NOTE: 4MHz has only 2
!                                              !       parts with EMIR
backend /clear
BACKEND 4MHz       /Default                    ! connect 1 part to each of
!                                              ! the first 2 EMIR subbands
pause
!
BACKEND 4MHZ 1    /Receiver E090 Horiz LI      ! connect 1 part to E090 Ho LI
BACKEND 4MHZ 2    /Receiver E230 Verti LI      !       2nd part to E230 Ve LI
pause
!
!                                              ! EMIR FTS wide bandwidth mode
!                                              !    /Fine is NOT present
backend /clear
BACKEND FTS        /Default                    ! connect 1 part to
!                                              ! each selected EMIR subband
!                                              ! plus 1 part to each of the
!                                              ! 4 outer subbands of E090
pause
!
backend /clear
!                                              ! short syntax (still wide)
BACKEND FTS 1        /Receiver E090 hor LI     !
BACKEND FTS 2        /Receiver E090 ver LI     !
BACKEND FTS 3        /Receiver E230 hor LI     !
BACKEND FTS 4        /Receiver E230 ver LI     !
BACKEND FTS 5        /Receiver E090 ver LO     !
BACKEND FTS 6        /Receiver E230 ver LO     !
BACKEND FTS 7        /Receiver E090 hor LO     !
BACKEND FTS 8        /Receiver E230 hor LO     !
!                                              !
pause
!
!                                              ! EMIR FTS fine resolution
!                                              !   because /Fine is present
backend /clear
BACKEND FTS   /Fine  /Default                  ! connect 1 part to
!                                              ! each selected EMIR subband
!                                              ! plus 1 part to each of
!                                              ! the 4 outer subbands of E090
pause
!
backend /clear
!                                              ! short syntax (fine)
BACKEND FTS 1 /Fine  /Receiver E090 hor LI     !
BACKEND FTS 2 /Fine  /Receiver E090 ver LI     !
BACKEND FTS 3 /Fine  /Receiver E230 hor LI     !
```

```
BACKEND FTS 4 /Fine  /Receiver E230 ver LI    !
BACKEND FTS 5 /Fine  /Receiver E090 ver LO    !
BACKEND FTS 6 /Fine  /Receiver E230 ver LO    !
BACKEND FTS 7 /Fine  /Receiver E090 hor LO    !
BACKEND FTS 8 /Fine  /Receiver E230 hor LO    !
!                                             !
pause
!
!
!                                             ! EMIR WILMA + 4MHz + VESPA
backend /clear
BACKEND WILMA      /Default                   !
BACKEND 4MHz       /Default                   !
BACKEND VESPA  1   0.040   40.0    0.0   E090  Horiz  LI
BACKEND VESPA  2   0.040   40.0    0.0   E090  Verti  LI
BACKEND VESPA  3   0.040   40.0    0.0   E230  Horiz  LI
BACKEND VESPA  4   0.040   40.0    0.0   E230  Verti  LI
say                                          " ! backends can be combined"
pause
!
!
!! EMIR VESPA autocorrelator -- basic mode with fShift. optional: line name
!
backend /clear
BACKEND VESPA  1   0.040   40.0  -120.0  E090  Horiz  LI /line E0HU0-M
BACKEND VESPA  2   0.040   40.0   120.0  E090  Horiz  LI /line E0HU0-P
BACKEND VESPA  3   0.040   40.0  -100.0  E090  Verti  LI /line myLine3
BACKEND VESPA  4   0.040   40.0   110.0  E090  Verti  LI /line myLine4
BACKEND VESPA  5   0.040   80.0  -150.0  E230  Horiz  LI /line ""
BACKEND VESPA  6   0.040   80.0   150.0  E230  Horiz  LI /line apple
BACKEND VESPA  7   0.040   80.0  -200.0  E230  Verti  LI /line orange
BACKEND VESPA  8   0.040   80.0   200.0  E230  Verti  LI /line red
pause
!
!! EMIR VESPA autocorrelator -- basic and parallel modes
!
backend /clear
BACKEND VESPA  1   0.320  240.0    0.0   E090  Horiz  LI
BACKEND VESPA  2   0.320  240.0    0.0   E090  Verti  LI
BACKEND VESPA  3   0.320  240.0    0.0   E230  Horiz  LI /mode parallel
pause
!
!! NOTE: BACKEND VESPA ... E230 Horiz LI /mode parallel
!!       connects one VESPA part in parallel to
!!       E230 Horiz LI and E230 Verti LI
!!       (both must be selected in RECEIVER command)
!
!
!! HERA with FTS wide bandwidth
!
receiver /clear
RECEIVER HERA1 /WIDTH wide
RECEIVER HERA2 /WIDTH wide
!
```

```
backend /clear
BACKEND FTS 1           /RECEIVER HERA1
BACKEND FTS 2           /RECEIVER HERA2
!
!
!! HERA narrow bandwidth with FTS fine resolution
!
receiver /clear
RECEIVER HERA1 /WIDTH narrow
RECEIVER HERA2 /WIDTH narrow
!
backend /clear
BACKEND FTS 1   /FINE   /RECEIVER HERA1
BACKEND FTS 2   /FINE   /RECEIVER HERA2
!
```

7.3 CALIBRATE

```
CALIBRATE (no parameters)

Specify a calibration measurement with the heterodyne receivers,
normally with subscans "SAC": Sky -- Ambient temperature load -- Cold load

NOTE: CALIBRATE is always and automatically done with switching mode "total
and the time per phase is adjusted to be in the range 0.1 to 0.5 [sec]

/SKY xOffsetC yOffsetC
or
/SKY NO                         ! do not do sky calibration

Do a calibration subscan on sky.

Real      :: xOffsetC          ! x-offset
Real      :: yOffsetC          ! y-offset

NOTES: with the usage /SKY xOffsetC yOffsetC, both parameters are required,
but you can replace either parameter with * to leave it unchanged.
The system for the offsets is selected through the option /SYSTEM.
```

7.3.1 CALIBRATE /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.3.2 CALIBRATE /AMBIENT

```
/AMBIENT [yes|no]

Do a calibration subscan on the ambient temperature load.

Logical   :: doAmbient        ! default: true
```

7.3.3 CALIBRATE /COLD

```
/COLD [yes|no]

Do a calibration subscan on the cold temperature load.

Logical   :: doCold           ! default: true
```

7.3.4 CALIBRATE /GAINIMAGE

```
 --> NOTE: OBSOLETE WITH CHANGE TO EMIR
```

7.3.5 CALIBRATE /GRID

```
/GRID [yes|no]

NOT YET AVAILABLE FOR EMIR

Do a calibration subscan on a grid.  This is a special calibration
option for polarization observations.

Logical   :: doGrid           ! default: true

IMPORTANT NOTE:
remember to turn this option off again for normal calibrations:
e.g., CALIBRATE /GRID NO or CALIBRATE /DEFAULT.
```

7.3.6 CALIBRATE /SKY

```
/SKY xOffsetC yOffsetC
or
/SKY NO                        ! do not do sky calibration

Do a calibration subscan on sky.

Real      :: xOffsetC          ! x-offset
Real      :: yOffsetC          ! y-offset
```

```
NOTES: with the usage /SKY xOffsetC yOffsetC, both parameters are required,
but you can replace either parameter with * to leave it unchanged.
The system for the offsets is selected through the option /SYSTEM.
```

7.3.7 CALIBRATE /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
```

```
(cleared), for the MAMBO bolometer, Nasmyth offsets are used
automatically according to the selected bolometer channel (pixel).
```

7.3.8 CALIBRATE /TCALIBRATE

```
/TCALIBRATE tCalibrate

Time per CALIBRATE subscan.

Real       :: tCalibrate       ! time
```

7.4 CATALOG

```
CATALOG [SOURCE|LINE] fileName

Select a source or line catalog.

Character :: kind              ! SOURCE or LINE
Character :: fileName          ! file name

Selects a file with name fileName as source or line catalog.


Source Catalog:

The format of a line in the source catalog is the same as
that of the parameters of the SOURCE command, without the
keyword "SOURCE" and without any options (see HELP SOURCE). Example:

W3OH EQ 2000 02:27:03.8812  +61:52:24.572  LSR -45.0 [FLUX 3.73 1.00]

IMPORTANT NOTE:
sourceName is limited to 12 characters.


Line Catalog:

The format of a line in the line catalog is same as that of the
2nd, 3rd, and 4th parameter of the RECEIVER command:

lineName        frequency       SB

with frequency in unit [GHz] (see HELP RECEIVER).
Example:

12CO(1-0)       115.271204      UI      (for EMIR)
```

```
12CO(2-1)       230.537990      LI      (for EMIR)
12CO(2-1)       230.537990      LSB     (for HERA)

IMPORTANT NOTE:
lineName is limited to 12 characters.

NB: Don't use / & < > in names of sources, lines, projects,
PI, observer, operator, etc. Don't use ()/ in source names.
```

7.4.1 CATALOG SOURCE

```
Source Catalog:

The format of a line in the source catalog is the same as
that of the parameters of the SOURCE command, without the
keyword "SOURCE" and without any options (see HELP SOURCE). Example:

W3OH EQ 2000 02:27:03.8812  +61:52:24.572  LSR -45.0 [FLUX 3.73 1.00]

IMPORTANT NOTE:
sourceName is limited to 12 characters.
```

7.4.2 CATALOG LINE

```
Line Catalog:

The format of a line in the line catalog is same as that of the
2nd, 3rd, and 4th parameter of the RECEIVER command:

lineName        frequency       SB

with frequency in unit [GHz] (see HELP RECEIVER).
Example:

12CO(1-0)       115.271204      UI      (for EMIR)
12CO(2-1)       230.537990      LI      (for EMIR)
12CO(2-1)       230.537990      LSB     (for HERA)

IMPORTANT NOTE:
lineName is limited to 12 characters.
```

7.5 DISPLAY

```
DISPLAY REDO

Redo (refresh) the text in the display window.
```

7.6 DIYLIST

```
DIYLIST

User-defined list of subscans and segments for observing mode "DIY";
to define subscans, see HELP SUBSCAN.

NB: this is a protected command (needs privilege).

DIYLIST without any parameters or options:

  - lists defined subscans and segments in the pako window
    (this requires SET LEVEL 2 or lower)
  - in the pakoDisplay shows conditions, e.g., maximum possible elevation
  - plots defined subscans and segments (depending on SET plotStyle)
```

7.6.1 DIYLIST /CLEAR

```
/CLEAR  [yes|no]

Completely clear the used-defined list of subscans and segments DIY.
```

7.6.2 DIYLIST /PURPOSE

```
/PURPOSE purpose

Set a purpose for a scan, i.e., an intended use of the data.
The applies in particular to DIYLIST.

Character :: purpose            !

NOTE: /PURPOSE by itself or
      /DIY     clears the purpose.

NOTE: at this time (2012-11-08) this is only for information,
and included in the XML, but it has no practical effect.
```

7.7 FOCUS

```
FOCUS lengthFocus

Specify a focus measurement.

Real      :: lengthFocus       ! length [mm] of focus scan


The sequence of focus subscans is determined by
lengthFocus /nSubscans /otfFocus:

 lengthFocus     ! total length [mm] of the focus scan
 /nSubscans      ! number of focus subscans
 << TD:/otfFocus       ! not yet implemented>>

 focus subscan 1 is at offset  0.0
 focus subscan 2 is at offset  lengthFocus/2
 in case /nSubscans 3:
 focus subscan 3 is at offset -lengthFocus/2
 in case /nSubscans >3:
 focus subscan 3 is at offset  lengthFocus/2
 focus subscan 4 is at offset -lengthFocus/2
 focus subscan 5 is at offset -lengthFocus/2
 focus subscan 6 is at offset  0.0
 (etc.)
```

7.7.1 FOCUS /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.7.2 FOCUS /NSUBSCANS

```
/NSUBSCANS nSubscans

Integer   :: nSubscans         ! number of subscans
```

7.7.3 FOCUS /TSUBSCAN

```
/TSUBSCAN tSubscan

time per subscan

Real       :: tSubscan         ! time
```

7.7.4 FOCUS /TUNE

```
/TUNE xOffsetT yOffsetT
or
/TUNE NO                  ! no tune subscan

Tune subscan at the specified offsets, before any other subscans.

Real      :: xOffsetT          ! x-offset for tune subscan
Real      :: yOffsetT          ! y-offset for tune subscan

NOTE: with the usage /TUNE xOffsetT yOffsetT, both parameters are required,
but you can replace either parameter with * to leave it unchanged.

For FOCUS, the offsets for the tune subscan are in the
"trueHorizontal" system.
```

7.7.5 FOCUS /TTUNE

```
/TTUNE tTune

time per TUNE subscan

Real       :: tTune             ! time
```

7.7.6 FOCUS EXAMPLES

```
!
! Id: demo-focus.pako
!     FOCUS EXAMPLE,v 1.1.1 2009-05-08 Hans Ungerechts
!
SWBEAM                                        !  to select beam switching
!
FOCUS            2.0                        - !  length [mm]
  /NSUBSCANS     6                          - !  number of subscans
  /TSUBSCAN     12                            !  time per subscan
!
PAUSE "FOCUS OK to start? [c/q]"              !  a chance to check
!
START                                         !  start
!
!! Comments:
!! We assume here that a pointing measurement has been done
!! immediately before the FOCUS (strongly recommended!),
!! see: demo-pointing, and therefore
!! we assume here that source, receivers, and backends
!! already have been selected and set up.
!! If you want the intensity of the Focus data to be
!! calibrated, you have to do a Calibrate with the same
!! receivers and (continuum) backends before.
```

7.8 LISSAJOUS

```
LISSAJOUS    xAmplitude   yAmplitude
  /CENTER    xCenter      yCenter
  /FREQUENCY frequencyX   frequencyY
  /PHASES    phiX         phiY
  /TOTF      tOtf
  /SYSTEM    system

additionally for NIKA:

  /FOCUS     f1 f2 [... f18] [direction]
  /POINTING  [yes|no]
  /TUNE      xOffsetT     yOffsetT
  /TTUNE     tTune

Specify an On-The-Fly (OTF) map with a Lissajous curve in 1 subscan.
LISSAJOUS is at this time (2014-11-10) supported only for GISMO and NIKA

Real      :: xAmplitude        ! amplitude for x-offsets
Real      :: yAmplitude        ! amplitude for y-offsets
Real      :: xCenter           ! center x-offset
Real      :: yCenter           ! center y-offset
Real      :: frequencyX        ! frequency    [Hz]  for x
Real      :: frequencyY        ! frequency    [Hz]  for y
Real      :: phiX              ! phase offset [rad] for x
Real      :: phiY              ! phase offset [rad] for y

Real      :: tOtf              ! time [s]
Character :: systemName        ! name of system, one of:
                               ! PROJECTION
                               ! TRUEHORIZON

Real      :: f1 f2 [... f18]   ! focus offset [mm] during each Lissajous cur
Character :: direction         ! direction of focus offsets, one of:
                               ! X
                               ! Y
                               ! Z

Real      :: xOffsetT          ! x-offset for tune subscan
Real      :: yOffsetT          ! y-offset for tune subscan
Real      :: tTune             ! time [s] for tune subscan


During a Lissajous OTF segment, the position offsets
x and y as a function of time t are:

x = xCenter + xAmplitude * SIN(2 Pi frequencyX t + phiX)
y = yCenter + yAmplitude * SIN(2 Pi frequencyY t + phiY)

SIN is the usual sine function, Pi is the number Pi.
```

```
xAmplitude yAmplitude xCenter yCenter are in angle units ([arc sec])
frequencyX frequencyY                 are in [Hz]
phiX       phiY                       are in [rad]

Note that the possible frequencies are very low,
typically 0.01 to 0.15 Hz.

At the start of a Lissajous subscan, paKo will insert a "ramp" along a
straight line, i.e., a linear OTF segment, increasing the count of
segments by 2.  This ramp up starts with speed 0 relative to the
source and joins smoothly with the start position and velocity of the
Lissajous segment.  The purpose is to avoid a sudden acceleration at
the start of the Lissajous segment.  The inserted ramp up
segment and the Lissajous segment become part of the same subscan.

Lissajous curves with large amplitudes or frequencies can reach the
antenna's speed and acceleration limits for tracking.  Lissajous
curves can be executed only for elevations less than a maximum, which
depends on the Lissajous parameters.  For information, this elevation
condition is shown by pako. Even below the limits, during very fast
Lissajous curves the tracking errors will be higher, several arc sec,
than during most other observations.

DO NOT TRY TO OBSERVE LISSAJOUS ABOVE THIS MAXIMUM ELEVATION.
```

7.8.1 LISSAJOUS /CENTER

```
/CENTER    xCenter      yCenter

position of center

Real      :: xCenter           ! center x-offset
Real      :: yCenter           ! center y-offset
```

7.8.2 LISSAJOUS /FREQUENCY

```
/FREQUENCY frequencyX   frequencyY

Real      :: frequencyX        ! frequency    [Hz]  for x
Real      :: frequencyY        ! frequency    [Hz]  for y
```

7.8.3 LISSAJOUS /PHASES

```
/PHASES    phiX         phiY

Real      :: phiX              ! phase offset [rad] for x
Real      :: phiY              ! phase offset [rad] for y
```

7.8.4 LISSAJOUS /SYSTEM

```
/SYSTEM systemName
```

```
Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.8.5 LISSAJOUS /TOTF

```
/TOTF tOtf
```

```
time per OTF subscan or segment

Real       :: tOtf             ! time

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

7.8.6 LISSAJOUS /FOCUS

```
/FOCUS f1 f2 [... f18] [direction]
or
/FOCUS NO

[For Lissajous] designate the purpose of the scan to be "Focus", i.e.,
to determine focus corrections.  A subscan with a Lissajous curve will
be executed for each focus offset specified.

Real      :: f1 f2 [... f18]   ! focus offsets [mm]
                               ! (at least 2, at most 18 values)
Character :: direction         ! direction of focus offsets, one of:
                               ! X
                               ! Y
                               ! Z

/FOCUS NO clears the option /FOCUS.
```

7.8.7 LISSAJOUS /POINTING

```
/POINTING [YES|NO]

Logical   :: doPointing      ! default: no

[For Lissajous] designate the purpose of the scan to be "Pointing",
i.e., to determine pointing corrections.

/POINTING NO clears the option /POINTING.
```

7.8.8 LISSAJOUS /TUNE

```
/TUNE xOffsetT yOffsetT
or
/TUNE NO                  ! no tune subscan

Tune subscan at the specified offsets, before any other subscans.

Real      :: xOffsetT          ! x-offset for tune subscan
Real      :: yOffsetT          ! y-offset for tune subscan

NOTE: with the usage /TUNE xOffsetT yOffsetT, both parameters are required,
but you can replace either parameter with * to leave it unchanged.

The offsets for the tune subscan are in the system selected with /SYSTEM.
```

7.8.9 LISSAJOUS /TTUNE

```
/TTUNE tTune

time per TUNE subscan

Real       :: tTune             ! time
```

7.9 OFFSETS

```
OFFSETS xOffset yOffset

Specify source offsets.

Real      :: xOffset           ! x-offset
Real      :: yOffset           ! y-offset

IMPORTANT NOTE: one should be careful with the OFFSETS command, which
is only used and only needed in a few special situations, e.g., with
Wobbler-switching ONOFF and to set NASMYTH offsets for
focal-plane-array receivers.  The function of OFFSETS is explained in
the paKo user's manual, Section "A Guide to the Perplexed" and, in
more detail, in the Section "NCS Explained", Subsection "Coordinate
Systems, Projections, and Offsets."

For many observations all "offsets" are specified as parameters or
options of the command for the observing mode.

/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.
```

```
TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.9.1 OFFSETS /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.9.2 OFFSETS /CLEAR

```
/CLEAR  [yes|no]

Completely clear a list of connected hardware, e.g., receivers, backends,
or parameters of the associated command.
```

7.9.3 OFFSETS /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.
```

```
Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.10 ONOFF

```
ONOFF xOffset yOffset
```

```
Specify on-off measurement, a.k.a. "position switching".

Real      :: xOffset           ! x-offset of "on-source" position
Real      :: yOffset           ! y-offset of "on-source" position

Character :: sourceName        ! name of "on-source" position

NOTE: if SWWOBBLER is the selected switching mode, the special option
/SWWOBBLER YES (TRUE) is implied even without specifying it, and the
on-off parameters appropriate for on-off Wobbler switching are set.


If SWWOBBLER and ONOFF are combined in the standard way, we
effectively take data at 3 positions:

1. the source position
2. the source position + throw  (offset in the "true-angle" horizontal syste
3. the source position - throw  (offset in the "true-angle" horizontal syste

with throw = ABS(wOffset2-wOffset1).

Data from 1. are treated as source signal, data from 2 and 3 as
off-source reference signal.  Note that in the astronomical
coordinates, positions 2 and 3 will rotate around the source position
(1).  Therefore one must normally be sure that the extent of the source
is less than throw-beamWidth (/2).


/REFERENCE xOffsetR yOffsetR [systemNameRef]
or
/REFERENCE NO                  ! no reference

position of off-source reference subscans

Real      :: xOffsetR          ! x-offset
Real      :: yOffsetR          ! y-offset
Character :: systemNameRef     ! name of system
                               ! see /SYSTEM for choices

NOTE: with the usage /REFERENCE xOffsetR yOffsetR, both parameters are requi
but you can replace either parameter with * to leave it unchanged.

/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
```

```
<<TBD:                          ! EQUATORIAL>>
<<TBD:                          ! HADECL>>
<<TBD:                          ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.10.1 ONOFF /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.10.2 ONOFF /NSUBSCANS

```
/NSUBSCANS nSubscans

Integer   :: nSubscans         ! number of subscans
```

7.10.3 ONOFF /REFERENCE

```
/REFERENCE xOffsetR yOffsetR [systemNameRef]
or
/REFERENCE NO                  ! no reference

position of off-source reference subscans

Real      :: xOffsetR          ! x-offset
Real      :: yOffsetR          ! y-offset
Character :: systemNameRef     ! name of system
                               ! see /SYSTEM for choices

NOTE: with the usage /REFERENCE xOffsetR yOffsetR, both parameters are requi
but you can replace either parameter with * to leave it unchanged.
```

7.10.4 ONOFF /SWWOBBLER

```
/SWWOBBLER [yes|no]

(option of command ONOFF)

set parameters appropriate for on-off Wobbler switching

Logical   :: doSwWobbler

If switching mode SWWOBBLER has been selected, the following parameters
of ONOFF are set according to wOffset1 and wOffset2:

ONOFF
      xOffset        is set to: -wOffset1
      yOffset        is set to:  0.0

/REFERENCE           is set to:  Yes
      xOffsetR       is set to: -wOffset2
      yOffsetR       is set to:  0.0
      systemNameRef  is set to:  TRUEHORIZON

/SYSTEM
      systemName     is set to:  TRUEHORIZON

NOTE: in this case the values selected by /SWWOBBLER overrule the
corresponding values specified directly in the command.

NOTE: To do ONOFF with Wobbler switching and other (unconventional)
values for the parameters listed above, simply specify the values
using command ONOFF with option /SWWOBBLER NO (not recommended).

NOTE: If the selected switching mode is SWWOBBLER and if the option
/SWWOBBLER is no explicitly given, it will be assumed to be .True. (Yes),
If the selected switching mode is not SWWOBBLER and if the option
/SWWOBBLER is no explicitly given, it will be assumed to be .False. (No),
```

7.10.5 ONOFF /SYMMETRIC

```
/SYMMETRIC [yes|no]

Logical   :: doSymmetric      ! default: no

(For ONOFF) select a subscan sequence that is "symmetric" in time.
This requires that the number of subscans is a multiple of 4.

Example for ONOFF with /SYMMETRIC no     /SYMMETRIC yes
1st subscan:                      OFF               OFF
2nd  "                            ON                ON
3rd  "                            OFF               ON
4th  "                            ON                OFF
(and so on)

NOTE that this does not in anyway change the positions
of the ON-source and OFF-source subscans!
```

7.10.6 ONOFF /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
```

```
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.10.7 ONOFF /TSUBSCAN

```
/TSUBSCAN tSubscan

time per subscan

Real       :: tSubscan         ! time
```

7.10.8 ONOFF EXAMPLES

```
!
! Id: demo-onoff.pako
!     ONOFF SWTOTAL EXAMPLE,v 1.1.1 2009-05-05 Hans Ungerechts
!     "POSITION SWITCHING"
!
@ demo-rx-spectrometers                     !  demo setup of receivers
!                                           !  and spectrometers
!                                           !  REPLACE WITH YOUR SETUP!
!
SET ANGLE arcsec                            !
!
SWTOTAL                                   - !  select total power
  /TPHASE        0.5                        !  time per phase (data sample)
!
CALIBRATE                                 - !
  /AMBIENT                                - !  ambient load
  /COLD                                   - !  cold    load
  /SKY       -600.0   0.0                 - !  sky at offsets -600.0 0.0
  /SYSTEM       projection                - !  system for SKY offsets
  /TCALIBRATE   5.0                         !  time per calibration subscan
!
PAUSE "CALIBRATE OK to start? [c/q]"        !  a chance to check
!
```

```
START                                        !  start
!
ONOFF           40.0   -30.0              - !  offsets of on position
  /NSUBSCANS    12                       - !  number of subscans
  /REFERENCE  -600.0     0.0   projection - !  offsets of off-source referen
  /SYSTEM       projection               - !  system for offsets
  /SYMMETRIC                             - !  "symmetric" subscan sequence
  /TSUBSCAN     30                         !  time per subscan
!
PAUSE "ONOFF SWTOTAL OK to start? [c/q]"    !  a chance to check
!
START                                        !  start
!
!! Comments:
!! we assume here that the source already has been selected,
!! see: demo-source

!
! Id: demo-onoff-swwobbler.pako
!     ONOFF SWWOBBLER EXAMPLE,v 1.1.6 2011-07-31 Hans Ungerechts
!     "WOBBLER SWITCHING"
!
@ demo-rx-spectrometers                      !  demo setup of receivers
!                                            !  and spectrometers
!                                            !  REPLACE WITH YOUR SETUP!
!
SET ANGLE arcsec                             !
!
!                                            !  select wobbler switching
SWWOBBLER     -120.0   120.0              - !  wobbler -/+ 120 arc sec
  /TPHASE        1.0                         !  1 seconds per phase
!
CALIBRATE                                  - !
  /AMBIENT                                 - !  ambient load
  /COLD                                    - !  cold    load
  /SKY       -600.0   0.0                  - !  sky at offsets -600.0 0.0
  /SYSTEM       projection                 - !  system for SKY offsets
  /TCALIBRATE   5.0                          !  time per calibration subscan
!
PAUSE "CALIBRATE OK to start? [c/q]"        !  a chance to check
!
START                                        !  start
!
!!                                           !  OPTIONAL:
!! OFFSETS  20 30                          - !  mapping offsets in
!!  /SYSTEM projection                      !  system projection
!
ONOFF   /SWWOBBLER                         - !  ONOFF for Wobbler switching
  /NSUBSCANS    12                       - !  number of subscans
  /SYMMETRIC                               - !  "symmetric" subscan sequence
  /TSUBSCAN     30                         !  time per subscan
!
PAUSE "ONOFF SWWOBBLER OK to start? [c/q]"  !  a chance to check
!
```

```
START                                        !  start
!
!! Comments:
!! we assume here that the source already has been selected,
!! see: demo-source
!!
!! IMPORTANT NOTE: ONOFF with SWWOBBLER (wobbler switching on-off)
!! requires that the subscans are offset relative to the source
!! in the trueHorizon system by -1 * the  Wobbler elongations (offsets).
!! With the commands above, paKo recognizes this and automatically
!! sets the correct values.
!! In this case, OFFSETS can be used to set additional mapping
!! offsets in the  "projection" of the astronomical coordinate
!! system.  These mapping offsets in the projection apply
!! to all ONOFF subscans.
```

7.11 OTFMAP

```
OTFMAP xStart yStart xEnd yEnd

Specify an On-The-Fly (OTF) map with linear OTF subscans.

Real      :: xStart            ! x-offset of start of first OTF  subscan
Real      :: yStart            ! y-offset of start of first OTF  subscan
Real      :: xEnd              ! x-offset of end   of first OTF  subscan
Real      :: yEnd              ! y-offset of end   of first OTF  subscan

The sequence of subscans is determined by:
/croLoop /nOtf /reference /step /zigzag

/croLoop     sequence of:
             R off-source Reference
             O on-source OTF
/nOtf        number of OTF subscans
/reference   off-source reference position
/step        step in x and y between OTF subscans
             = translation of one OTF subscans to the next
/zigzag      option to scan back-and-forth

The scan analysis loops through the letter codes in croLoop until nOtf
OTF subscans have been generated, starting with first letter in the
croLoop.

   IF THE CROCODE LETTER IS "R" AND /REFERENCE IS TRUE:

   1 subscan tracking the fixed off-source reference position
   is generated

   IF THE CROCODE LETTER IS "O":

   1 linear OTF subscan is generated.
```

```
   - The start and end positions of the first OTF subscan are:
     parameters xStart yStart xEnd yEnd of the OTFMAP command
   - For the second and all following OTF subscans:
     xStart yStart xEnd yEnd of the previous OTF subscan are
     incremented by parameters dx and dy of option /step.
     If /zigzag is true, xStart yStart and xEnd yEnd are
     interchanged.

Then the next letter code in the croLoop is considered
in the same way.

If /reference is true, a croCode ending in "R" will ensure that an
off-source reference subscan follows the last OTF subscan.

/CROLOOP croLoop

sequence of R = off-source Reference
            O = On-source subscans

Character :: croLoop

Example:
/croLoop ROOR

/NOTF nOtf

Integer   :: nOtf              ! number of OTF (on-the-fly) subscans

/REFERENCE xOffsetR yOffsetR [systemNameRef]
or
/REFERENCE NO                  ! no reference

position of off-source reference subscans

Real      :: xOffsetR          ! x-offset
Real      :: yOffsetR          ! y-offset
Character :: systemNameRef     ! name of system
                               ! see /SYSTEM for choices

NOTE: with the usage /REFERENCE xOffsetR yOffsetR, both parameters are requi
but you can replace either parameter with * to leave it unchanged.

/STEP dx dy

Step (shift or translation)  between lines in a map.

Real      :: dx                ! shift in x-offsets
Real      :: dy                ! shift in y-offsets

/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
```

```
                                ! PROJECTION
                                ! TRUEHORIZON
                                ! NASMYTH

<<TBD:                          ! DESCRIPTIVE>>
<<TBD:                          ! BASIS>>
<<TBD:                          ! EQUATORIAL>>
<<TBD:                          ! HADECL>>
<<TBD:                          ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.11.1 OTFMAP /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.11.2 OTFMAP /CROLOOP

```
/CROLOOP croLoop

sequence of R = off-source Reference
            O = On-source subscans

Character :: croLoop

Example:
/croLoop ROOR
```

7.11.3 OTFMAP /NOTF

```
/NOTF nOtf

Integer   :: nOtf              ! number of OTF (on-the-fly) subscans
```

7.11.4 OTFMAP /REFERENCE

```
/REFERENCE xOffsetR yOffsetR [systemNameRef]
or
/REFERENCE NO                  ! no reference

position of off-source reference subscans

Real      :: xOffsetR          ! x-offset
Real      :: yOffsetR          ! y-offset
Character :: systemNameRef     ! name of system
                               ! see /SYSTEM for choices

NOTE: with the usage /REFERENCE xOffsetR yOffsetR, both parameters are requi
but you can replace either parameter with * to leave it unchanged.
```

7.11.5 OTFMAP /STEP

```
/STEP dx dy

Step (shift or translation)  between lines in a map.

Real      :: dx                ! shift in x-offsets
Real      :: dy                ! shift in y-offsets
```

7.11.6 OTFMAP /SPEED

```
/SPEED speed1 [speed2]

speed of OTF subscans

Real      :: speed1            ! speed at start
Real      :: speed2            ! speed at end
```

```
For OTFMAP speed2 = speed1.

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

7.11.7 OTFMAP /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
```

```
(in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
(cleared), for the MAMBO bolometer, Nasmyth offsets are used
automatically according to the selected bolometer channel (pixel).
```

7.11.8 OTFMAP /TOTF

```
/TOTF tOtf

time per OTF subscan or segment

Real       :: tOtf             ! time

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

7.11.9 OTFMAP /TREFERENCE

```
/TREFERENCE tReference

time per off-source reference

Real       :: tReference       ! time
```

7.11.10 OTFMAP /ZIGZAG

```
/ZIGZAG [yes|no]

alternate direction between lines in a map

Logical    :: doZigzag
```

7.11.11 OTFMAP /TUNE

```
/TUNE xOffsetT yOffsetT
or
/TUNE NO                  ! no tune subscan

Tune subscan at the specified offsets, before any other subscans.

Real      :: xOffsetT          ! x-offset for tune subscan
Real      :: yOffsetT          ! y-offset for tune subscan

NOTE: with the usage /TUNE xOffsetT yOffsetT, both parameters are required,
but you can replace either parameter with * to leave it unchanged.

The offsets for the tune subscan are in the system selected with /SYSTEM.
```

7.11.12 OTFMAP /TTUNE

```
/TTUNE tTune

time per TUNE subscan

Real       :: tTune             ! time
```

7.11.13 OTFMAP EXAMPLES

```
!
! Id: demo-otfmap.pako
!     OTFMAP SWTOTAL EXAMPLE,v 1.1.6 2011-07-21 Hans Ungerechts
!
@ demo-rx-spectrometers                     !  demo setup of receivers
!                                           !  and spectrometers
!                                           !  REPLACE WITH YOUR SETUP!
!
SET ANGLE arcsec                            !
!
SWTOTAL                                   - !  to select total power
  /TPHASE        0.5                        !  time per phase (data sample)
!
CALIBRATE                                 - !
  /AMBIENT                                - !  ambient load
  /COLD                                   - !  cold    load
  /SKY       -500.0 -400.0                - !  sky at offsets -500.0 -400.0
  /SYSTEM       projection                - !  system for SKY offset
  /TCALIBRATE   5.0                         !  time per calibration subscan
!
PAUSE "CALIBRATE OK to start? [c/q]"        !  a chance to check
!
START                                       !  start
!
OTFMAP        -300   -15  300  -15        - !  offsets at start and end of f
  /CROLOOP      ROR                       - !  subscans: reference-OTF-refer
  /NOTF          4                        - !  number of on-the-fly subscans
  /REFERENCE  -500  -400  projection      - !  offsets of off-source referen
  /STEP          0    10                  - !  step (shift) between OTF subs
  /SYSTEM       projection                - !  system for offsets
  /TOTF         120.0                     - !  time per on-the-fly subscan
  /TREFERENCE    20.0                     - !  time per off-source reference
  /ZIGZAG                                   !  go back and forth
!
PAUSE "OTFMAP SWTOTAL OK to start? [c/q]"   !  a chance to check
!
START                                       !  start
!
!! Comments:
!! we assume here that the source already has been selected,
!! see: demo-source
!!
```

```
!! /CROLOOP      ROR means that there will be an
!!               off-source reference subscan (R)
!!               before and after each OTF suscan (O).
!!               Therefore with /NOTF 4 on-the-fly subscans the complete
!!               subscan sequence will be:
!!               R OTF#1 R   R OTF#2 R   R OTF#3 R   R OTF#4 R
!!               with
!! /CROLOOP      ROOROOR it would be:
!!               R OTF#1       OTF#2   R   OTF#3       OTF#4 R
!
!
! Id: demo-otfmap-swfrequency.pako
!     OTFMAP SWFREQUENCY EXAMPLE,v 1.1.11 2011-11-25 Hans Ungerechts
!
@ demo-rx                                  !  demo setup of receivers
!
BACKEND /CLEAR                             !  clear previous backends
BACKEND VESPA 1 0.040 40.0 0.0 E090 hor LI  !  high spectral resolution
BACKEND VESPA 2 0.040 40.0 0.0 E090 ver LI  !  with VESPA
BACKEND VESPA 3 0.080 80.0 0.0 E230 hor LI
BACKEND VESPA 4 0.080 80.0 0.0 E230 ver LI
!                                          !  REPLACE WITH YOUR SETUP!
!
SET ANGLE arcsec                           !
!
!                                          !  setup frequency switching
SWFREQUENCY   -3.9     3.9  /receiver E090  !  for EMIR band E090
SWFREQUENCY  -11.7    11.7  /receiver E230  !  for EMIR band E230
SWFREQUENCY                 /tphase   0.20  !  same for all receivers/bands
!
CALIBRATE                                - !
  /AMBIENT                               - !  ambient load
  /COLD                                  - !  cold    load
  /SKY       -600.0   0.0                - !  sky at offsets -600.0 0.0
  /SYSTEM       projection               - !  system for offset
  /TCALIBRATE   5.0                        !  time per calibration subscan
!
PAUSE "CALIBRATE OK to start? [c/q]"       !  a chance to check
!
START                                      !  start
!
OTFMAP        -300  -300  300 -300       - !  offsets at start and end of f
  /CROLOOP      O                        - !  only OTF subscans
  /NOTF         4                        - !  number of on-the-fly subscans
  /REFERENCE    no                       - !  no off-source reference subsc
  /STEP          0    10                 - !  step (shift) between OTF subs
  /SYSTEM       projection                - !  system for offset
  /TOTF         120.0                     - !  time per on-the-fly subscan
  /ZIGZAG                                  !  go back and forth
!
PAUSE "OTFMAP SWFREQUENCY OK to start? [c/q]" !  a chance to check
!
START                                      !  start
!
```

```
!! Comments:
!! we assume here that the source already has been selected,
!! see: demo-source
```

7.12 POINTING

```
POINTING length

Specify a pointing measurement with linear OTF subscans in the
"true-angle" horizontal system, along azimuth and elevation, all
centered on the source.

Real      :: length            ! length (angle) of each subscan

The first subscan is incrementing in azimuth. If the number of OTF
subscans, nOtf, is 2, the second subscan is incrementing in
elevation.  If nOtf > 2, the subscan sequence is: incrementing
azimuth, decrementing azimuth, incrementing elevation, and if nOtf >
3: decrementing elevation, etc.
```

7.12.1 POINTING /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.12.2 POINTING /DOUBLEBEAM

```
/DOUBLEBEAM [yes|no]

Pointing: do a "double-beam" pointing

Logical    :: doDoubleBeam

This is valid only for pointing with Wobbler switching (SWWOBBLER).

This option has an effect only if SET 2nRotation 0.0
```

7.12.3 POINTING /NOTF

```
/NOTF nOtf

Integer   :: nOtf              ! number of OTF (on-the-fly) subscans
```

7.12.4 POINTING /TOTF

```
/TOTF tOtf

time per OTF subscan or segment

Real       :: tOtf             ! time

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

7.12.5 POINTING /TUNE

```
/TUNE xOffsetT yOffsetT
or
/TUNE NO                  ! no tune subscan

Tune subscan at the specified offsets, before any other subscans.

Real      :: xOffsetT          ! x-offset for tune subscan
Real      :: yOffsetT          ! y-offset for tune subscan

NOTE: with the usage /TUNE xOffsetT yOffsetT, both parameters are required,
but you can replace either parameter with * to leave it unchanged.

For POINTING, the offsets for the tune subscan are in the
"trueHorizontal" system.
```

7.12.6 POINTING /TTUNE

```
/TTUNE tTune

time per TUNE subscan

Real       :: tTune             ! time
```

7.12.7 POINTING EXAMPLES

```
!
! Id: demo-pointing.pako
!     POINTING EXAMPLE,v 1.1.11 2011-11-25 Hans Ungerechts
!
SOURCE   Mars                                !
OFFSETS /CLEAR                               !  clear previously set offsets
!
@ demo-rx                                    !  demo setup of EMIR
!                                            !  REPLACE WITH YOUR SETUP!
!
BACKEND /CLEAR                               !  clear previous backend setup
!
```

```
BACKEND BBC        /Default                 !  connect 1 part to each
!                                           !  EMIR subband selected
!
SET ANGLEUNIT arcsec                        !  make sure angle unit is arc s
!
SWBEAM                                      !  to select beam switching
!
POINTING /DEFAULT                           !  reset all options
!
POINTING      120                         - !  pointing with subscan length
   /NOTF       4                          - !  4 OTF subscans
   /TOTF      30.0                          !  30 seconds per OTF subscan
!
PAUSE "POINTING OK to start? [c/q]"         !  a chance to check
!
START                                       !  start
!
RETURN
!
!!
!! NOTE:
!! if you use NASMYTH offsets for an off-center pixel
!! of a mutlibeam receiver don't use OFFSETS/ CLEAR.
!! If you want the intensity of the Pointing data to be
!! calibrated, you have to do a Calibrate with the same
!! receivers and (continuum) backends before the pointing.
!!
```

7.13 RECEIVER

```
RECEIVER              receiverBand    lineName [frequency SB]
RECEIVER BOLOMETER    bolometerName   [pixel]

Specify selection and setup for receivers.

The first form is for heterodyne receivers,
the second form for bolometers.

Heterodyne:
===========

Character    :: receiverBand      ! name of receiver band to connect
Character*12 :: lineName          ! name of line. don't use @ < >
Real         :: frequency         ! [GHz]
Character    :: SB                ! sideband or subband
                                  ! choices for HERA: LSB USB
```

```
                                  ! choices for EMIR: LO LI UI UO

Choices for receiverBand are:
E090 E150 E230 E330 HERA1 HERA2

lineName is limited to 12 characters.


NB: Don't use / & < > in names of sources, lines, projects,
PI, observer, operator, etc. Don't use ()/ in source names.


E090 E150 E230 E330 are the 4 EMIR (Eight MIxer Receiver) bands,
HERA1 and HERA2     are the 2 parts of HERA (HEterodyne Receiver Array).

If only receiverBand and lineName are specified, we try to read the
frequency and sideband/subband from the line catalog specified with:
CATALOG LINE fileName.

The local oscillator for the receiverBand will be set so that the
frequency (corrected for the Doppler shift) will be in the requested
sideband/subband SB.  See receiver documentation for the exact values
of the IF.

NOTE: EMIR subbands, IF cables, and Backends

The output signals from EMIR are transmitted to the spectrometers and
NBC through 8 IF cables. Each IF cable carries one subband of bandwidth
4 GHz. This subbands are LO, LI, UI, or UO.

NBC, 4MHz, WILMA, and VESPA can only(!) be connected to IF cables 1 to 4.
FTS parts 1 to 4 can also be connected to IF cables 1 to 4.

The command options RECEIVER /HORIZONTAL and RECEIVER /VERTICAL allow
to select up to 4 EMIR subbands that will be transmitted through IF
cables 1 to 4 (compare HELP RECEIVER /HORIZONTAL and the EMIR user
documentation). This selection can include Outer subbands.

In addition, the IF cables 5 to 8 carry the 4 Outer subbands
corresponding to the subbands selected for IF cables 1 to 4. E.g., if
we select for IF 1 to 4:
E230 ver UO    E090 ver UI    E230 hor UI   E090 hor UI
then the IF cables 5 to 8 will transmit:
E230 ver UO    E090 ver UO    E230 hor UO   E090 hor UO.

Only FTS parts 5 to 8 can be connected to IF cables 5 to 8.

BACKEND NBC|WILMA|FTS /DEFAULT will automatically set the maximum
number of backend parts for all available subbands.

BACKEND BBC is completely independant of the sub band selections for
the IF cables.

Bolometer:
```

```
==========


RECEIVER BOLOMETER    bolometerName   [pixel]
RECEIVER BOLOMETER    GISMO
RECEIVER BOLOMETER    NIKA            [pixel]

Character :: bolometerName     ! name of bolometer
Integer   :: pixel             ! number of NIKA pixel

Choices for bolometerName are:
GISMO NIKA

If the pixel number is specified with RECEIVER BOLOMETER NIKA, pako
will try to find and use the Nasmyth offsets for this pixel in a
coresponding configuration file.

However, if Nasmyth offsets are explicitly specified with
OFFSETS /SYSTEM Nasmyth, the values from OFFSETS take precedence over
any values found for a NIKA pixel.
```

7.13.1 RECEIVER /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.13.2 RECEIVER /CLEAR

```
/CLEAR  [yes|no]

Completely clear a list of connected hardware, e.g., receivers, backends,
or parameters of the associated command.
```

7.13.3 RECEIVER /CONNECT

```
/CONNECT [yes|no]

connect (or disconnect) the specified hardware, e.g.,
backend or backend part.

 --> DEPRECATED. PROTECTED (needs SET userLevel)
```

7.13.4 RECEIVER /DEROTATOR

```
/DEROTATOR angle system
```

```
Specify derotator angle for HERA

Real      :: angle             ! in units [deg] (!)
Character :: system            !

Choices for system:
"Nasmyth"
"horizon"
"equatorial"
"frame"                        ! same as Nasmyth
"sky"                          ! same as equatorial

NOTES: The last 2 are for consistency with old control system and HERA conve
This option works only for RECEIVER HERA1 or RECEIVER HERA2 (of course it's
same angle for HERA1 and HERA2).
```

7.13.5 RECEIVER /DISCONNECT

```
/DISCONNECT

disconnect the specified hardware, e.g.,
backend or backend part.

 --> DEPRECATED. PROTECTED (needs SET userLevel)
```

7.13.6 RECEIVER /DOPPLER

```
/DOPPLER doppler

Character :: doppler           ! apply doppler correction?
                               ! choices: DOPPLER|FIXED
```

7.13.7 RECEIVER /EFFICIENCY

```
/EFFICIENCY forwardEfficiency beamEfficiency

specify forward and beam efficiencies

Real      :: forwardEfficiency !
Real      :: beamEfficiency    !
```

7.13.8 RECEIVER /GAINIMAGE

```
/GAINIMAGE gainImage [dB]

Specify the gain ratio of image to signal sidebands.
```

```
Real      :: gainImage         !

If "dB" is added after the value, the ratio is assumed to be in dB,
otherwise a decimal fraction.

--> A standard value for EMIR is -13 db, for HERA -10 db.
```

7.13.9 RECEIVER /HORIZONTAL

```
/HORIZONTAL [sb1 [sb2]]
/HORIZONTAL n[one]

EMIR subbands for Horizontal polarization.


This option applies only to EMIR.

Character   :: sb1, sb2   ! for EMIR: LO|LI|UI|UO

This option selects which EMIR subband(s) of this polarization will be
transmitted through IF cables 1 to 4.  Note that some backends, NBC,
4MHz, WILMA, VESPA, can only be connected to IF cables 1 to 4, i.e.,
only to the EMIR subbands selected with the RECEIVER command.

For each EMIR band and polarization, at most 2 subbands can be
transmitted through IF cables 1 to 4.  Which combinations of EMIR
bands, polarizations, and subbands are possibble is determined by the
hardware of the EMIR IF switching box.  See the EMIR documentation for
details.

If no subband is explicitly specified with this option, paKo will
assume that for this polarization the same single subband SB is
requested as specified for the main parameters (frequency, tuning) of
the RECEIVER command for this EMIR band.


/HORIZONTAL n[one] means that from this polarization no subband
will be transported through IF cables 1 to 4.
```

7.13.10 RECEIVER /SCALE

```
/SCALE scale

Select the calibration intensity scale.

Character :: scale             ! choices: ANTENNA|BEAM

If scale is "ANTENNA", the scale is antenna temperature.
If scale is "BEAM", the scale is (main) beam temperature.
```

7.13.11 RECEIVER /TEMPLOAD

```
/TEMPLOAD tempColdLoad tempAmbientLoad
/TEMPLOAD L[OOKUP]     L[OOKUP]
/TEMPLOAD *            ...

Set effective temperatures for the calibration loads at cold and ambient
temperature.

Real      :: tempColdLoad      !
Real      :: tempAmbientLoad   !

NEW LOGIC FOR SINGLE-PIXEL SIS RECEIVERS (FROM SUMMER 2007, paKo v1.0.7)

If a numerical value is entered for tempColdLoad or tempAmbientLoad,
that value is used for calibration calculations.

Instead of specifying a value one may enter the string L(OOKUP) for
tempColdLoad and/or tempAmbientLoad.  This is shown in the pakoDisplay
by the letter "L" instead of a number.

In this case, during the execution of the observations, the NCS will
use measured values for the corresponding load temperature(s).

A * can be substituted for tempColdLoad, which means to leave the
value for tempColdLoad unchanged from the previous RECEIVER command.

NOTE: FOR HERA
measured values are always used during the execution of the
observations. This is the same logic as in older versions of paKo/NCS.
```

7.13.12 RECEIVER /VERTICAL

```
/VERTICAL [sb1 [sb2]]
/VERTICAL n[one]

EMIR subbands for Vertical polarization


This option applies only to EMIR.

Character   :: sb1, sb2   ! for EMIR: LO|LI|UI|UO

This option selects which EMIR subband(s) of this polarization will be
transmitted through IF cables 1 to 4.  Note that some backends, NBC,
```

```
4MHz, WILMA, VESPA, can only be connected to IF cables 1 to 4, i.e.,
only to the EMIR subbands selected with the RECEIVER command.

For each EMIR band and polarization, at most 2 subbands can be
transmitted through IF cables 1 to 4.  Which combinations of EMIR
bands, polarizations, and subbands are possibble is determined by the
hardware of the EMIR IF switching box.  See the EMIR documentation for
details.

If no subband is explicitly specified with this option, paKo will
assume that for this polarization the same single subband SB is
requested as specified for the main parameters (frequency, tuning) of
the RECEIVER command for this EMIR band.


/VERTICAL n[one] means that from this polarization no subband
will be transported through IF cables 1 to 4.
```

7.13.13 RECEIVER /WIDTH

```
/WIDTH width

Select receiver setup for WIDE or NARROW bandwidth mode.

Character :: width             ! width. choices: WIDE|NARROW

NOTE: Option /WIDTH NARROW changes the (local oscillator) setup of
receivers HERA1 HERA2 in such a way that a line in the center of the
receiver bandwidth appears in the center of the bands of VESPA.

Spectrometers with 1GHz or more bandwidth normally require /WIDTH WIDE.

 --> NOTE: THIS OPTION DOES NOT APPLY TO EMIR!
```

7.13.14 RECEIVER BOLOMETER

```
RECEIVER BOLOMETER    bolometerName   [pixel]
RECEIVER BOLOMETER    GISMO
RECEIVER BOLOMETER    NIKA            [pixel]

Character :: bolometerName     ! name of bolometer
Integer   :: pixel             ! number of NIKA pixel

Choices for bolometerName are:
GISMO NIKA

If the pixel number is specified with RECEIVER BOLOMETER NIKA, pako
will try to find and use the Nasmyth offsets for this pixel in a
```

```
coresponding configuration file.

However, if Nasmyth offsets are explicitly specified with
OFFSETS /SYSTEM Nasmyth, the values from OFFSETS take precedence over
any values found for a NIKA pixel.
```

7.13.15 RECEIVER EXAMPLES

```
!
! Id: demo-receiver.pako
!     basic RECEIVER EXAMPLES,v 1.1.15 2013-10-14 Hans Ungerechts
!
CATALOG  line   demo-EMIR.lin      ! specify line catalog
!
RECEIVER /CLEAR                    ! clear all receivers previously set
!
say                              " !   --> E090 band from catalog
receiver /clear
RECEIVER E090   12CO(1-0)        - ! line (frequency, subband UO from catalo
               /Horizontal       - ! subband from catalog
               /Vertical           ! subband from catalog
say                              " ! NOTE: E090 band from catalog
pause
!
say                              " !   --> E090 band USB Outer subband
receiver /clear
REC E090 12CO(1-0) 115.271204 UO - ! line frequency and subband explicit
               /Horizontal UO    - ! USB Outer subband explicit
               /Vertical   UO      ! USB Outer subband explicit
say                              " ! NOTE: E090 H&V    UO   4 GHz BW
pause
!
!
say                              " !   --> E090+E150 bands LSB dual polariz.
receiver /clear
RECEIVER E090   HCN(1-0)         - !
               /Hor        LI    - ! LSB Inner subband
               /Ver        LI      ! LSB Inner subband
RECEIVER E150   CS(3-2)          - !
               /H          LI    - ! LSB Inner subband
               /V          LI      ! LSB Inner subband
say                              " ! NOTE: E090 H+V LI      4 GHz BW
say                              " !       E150 H+V LI      4 GHz BW
say                              " !   ++  E090 H+V LO      4 GHz BW for FTS
say                              " !   ++  E150 H+V LO      4 GHz BW for FTS
pause
!
!
say                              " !   --> E090+E230 bands LSB dual polariz.
receiver /clear
RECEIVER E090   HCN(1-0)         - !
               /Horizontal LI    - !
               /Vertical   LI      !
```

```
RECEIVER E230   12CO(2-1)        - !
               /Horizontal LI    - !
               /Vertical   LI      !
say                              " ! NOTE: E090 H+V LI      4 GHz BW
say                              " !       E230 H+V LI      4 GHz BW
say                              " !   ++  E090 H+V LO      4 GHz BW for FTS
say                              " !   ++  E230 H+V LO      4 GHz BW for FTS
pause
!
!
say                              " !   --> E150+E330 bands LSB dual polariz.
receiver /clear
RECEIVER E150   CS(3-2)          - !
               /H          LI    - !
               /V          LI      !
RECEIVER E330   13CO(3-2)        - !
               /H          LI    - !
               /V          LI      !
say                              " ! NOTE: E150 H+V LI      4 GHz BW
say                              " !       E330 H+V LI      4 GHz BW
say                              " !   ++  E150 H+V LO      4 GHz BW for FTS
say                              " !   ++  E330 H+V LO      4 GHz BW for FTS
pause
!
!!!!
!
RECEIVER      /clear
say                              " !   --> HERA1+HERA2 LSB
RECEIVER HERA1 12CO(2-1) 230.537990 LSB
RECEIVER HERA2 12CO(2-1) 230.537990 LSB
say                              " ! NOTE: HERA1+HERA2 LSB
pause
!
```

7.14 SAVE

```
SAVE [commandToSave]
SAVE ALL [CORRECTIONS]
SAVE SET [CORRECTIONS]
SAVE SWITCHING

Save parameters and options of a command in the form of a valid .pako
script.

Character :: commandToSave     ! command to save

If commandToSave is not specified, the last selected observing mode is
saved.

SAVE ALL saves (nearly) all current setup parameters, as well as the
```

```
current switching and observing modes, to file all.pako, or to a
different file specified with /FILE.

NOTE: SAVE ALL and SAVE SET save the pointing and focus corrections
only if they are used in the form
SAVE ALL C[ORRECTIONS]
SAVE SET C[ORRECTIONS]

(Normally SAVE ALL and SAVE SET are meant to generate paKo scripts
that can be used to re-produce the setup at a later time, when one
probably wants to use different corrections. On the other hand the
idiomatic usage: SAVE ALL C /FILE LAST allows to save "really
everything" in order to recover it with @ LAST)

SAVE SWITCHING saves the currently selected switching mode (total
power, beam, frequency, wobbler), to file switching.pako, or to a
different file specified with /FILE.

NOTE: the parameters of "unused" (unselected) hardware, switching
modes, and observing modes are never saved.
```

7.14.1 SAVE /APPEND

```
/APPEND [yes|no]

Append to existing file, do not create a new one.

Logical   :: doAppend        ! default: false
```

7.14.2 SAVE /FILE

```
/FILE fileName

Specify file name.

Character :: fileName          !
```

7.14.3 SAVE EXAMPLES

```
!
! SAVE EXAMPLES v1.0.0 2005-12-19 Hans Ungerechts
!
SOURCE ...
SWFREQUENCY ...
SWTOTAL ...
ONOFF  ...
OTFMAP ...
SAVE              ! saves OTFMAP       to file otfmap.pako
SAVE ALL          ! saves "everything" to file all.pako
SAVE ONOFF        ! saves ONOFF        to file onoff.pako
```

```
SAVE SOURCE       ! saves SOURCE       to file source.pako
SAVE SWITCHING    ! saves SWTOTAL      to file switching.pako
SAVE SWFREQUENCY  ! saves SWFREQUENCY  to file swfrequency.pako
!
```

7.15 SET

```
SET keyword   value [value* ...]

Set values for some general parameters.

Character               ::  keyword
Character|Integer|Real  ::  value*

Keywords    Type of Value(s)
========    ================

Level       Integer [Integer]  ! minumum value(s) for warning and error mess
Project     Character(len=24)  ! project ID
PI          Character(len=24)  ! PI. Don't use & < >
Observer    Character(len=24)  ! Observer(s). Don't use & < >
Operator    Character(len=24)  ! Telescope operator(s). Don't use & < >

Pointing    Real Real          ! Pointing corrections [arc sec]
Focus       Real               ! Focus correction [mm]
Topology    Character(len=24)  ! Topology for the overlapping azimuth range
2ndRotation Real               ! Rotation angle for Secondary and Wobbler

Comment     Character(len=128) ! Purpose. Don't use & < >
Purpose     Character(len=24)  ! Purpose. Don't use & < >

EMIRcheck   Character          ! "strict"|"relaxed"|"loose"

doSubmit    Logical            ! turn submission of jobs to queue on or off


NB: Don't use / & < > in names of sources, lines, projects,
PI, observer, operator, etc. Don't use ()/ in source names.


In  order  to include blank characters in a value of type Character, the
complete value should be included in " ", see example: SET Observer  be-
low.

Only  a  few  of these parameters are shown in the Display.  Use command
SHOW to list (nearly) all of them.
```

7.15.1 SET COMMENT

```
SET COMMENT comment
SET COMMENT ""

Comment     Character(len=128) ! Comment. Don't use & < >

Set comment for an observation.  The value of "comment" is displayed
in the monSDH display during the execution of each scan, and logged in
the iram30m-scan-*.xml files.

SET COMMENT ""
clears the comment.

NOTE: SET COMMENT can use values of variables, e.g.,
if 'ii' = 11  and 'imax' = 33 are variables in a loop:
PAKO> set comment " loop "'ii'" of "'imax'" executing "
I-SET,  Comment has been set to: loop 11 of 33 executing
PAKO> start
Then "loop 11 of 33 executing" will be shown in the monSDH when the
scan is executed.
```

7.15.2 SET DOSUBMIT

```
SET DOSUBMIT  YES|NO

Logical :: doSubmit

Turn submission of jobs to observing queue on or off.  (compare
command START).

IMPORTANT NOTE: to avoid any possible confusion, in each project
account at the 30-m telescope, only 1 running instance of Pako should
have SET DOSUBMIT YES!
```

7.15.3 SET FOCUS

```
SET FOCUS focus

Real :: focus               ! focus correction [mm]

Set focus correction in [mm]
```

7.15.4 SET LEVEL

```
SET LEVEL minimalForStandardOut [ minimalForFile ]

Integer ::  minimalForStandardOut  !  in range 0 to 9
Integer ::  minimalForFile         !  in range 0 to 9

Set minimal "level" for paKo "messages" to be written
1: interactively to the standard output, i.e., the terminal window
2: to the message log file pako.mes.

All paKo "messages" have an associated severity number.  With SET
LEVEL we can select that only messages with severity higher than
minimalForStandardOut (minimalForFile) are written.  Very serious
messages with severity 9 and higher can NOT be turned off.

The severity number for messages of kind:

I   is 1 or 2           Informational message
W   is 3 or 4           Warning       message
E   is 5 or 6           Error         message
F   is 7 or higher      Fatal Error   message

Example: SET LEVEL 5 3

Has the effect that "I" messages are not shown at all, and only "E"
and "F" messages are shown in the terminal window.
```

7.15.5 SET POINTING

```
SET POINTING azimuthCorrection [elevationCorrection]

Real :: azimuthCorrection   !  [arc sec]
Real :: elevationCorrection !  [arc sec]

Set pointing corrections in units of [arc sec]
*  in place of a number: leave the value unchanged

Example:
SET POINTING 1.1 2.2
```

7.15.6 SET PURPOSE

```
SET PURPOSE purpose
SET PURPOSE ""

Purpose     Character(len=24) ! Purpose. Don't use & < >

Choices for purpose are:

CALIBRATE FOCUS MAP POINTING TIP
```

```
Set purpose for an observation.  The value of "purpose" is displayed
in the monSDH display during the execution of each scan, and logged in
the iram30m-scan-*.xml files.  It may also be used elesewhere, e.g.,
in data handling software.

SET PURPOSE ""
clears the purpose.
```

7.15.7 SET 2NDROTATION

```
SET 2ndRotation rotation

Real :: rotation               ! rotation angle [deg]

Set rotation angle for the secondary mirror and Wobbler mechanism [deg].

The angle is limited to be between -50 and +50 [deg].

NOTE: Its sense is opposite to the mathematical convention!
(this will be changed in a future release of the NCS.)

The rotation angle is relative to the horizontal system.  A value of 0.0
corresponds to the Wobbler switching purely in Azimuth, i.e., "normal"
Wobbler switching.

Observers must inform the operator if they want to use this feature.

A non-zero values is up to know only meaningful and supported for
bolometer observations with Wobbler switching and the observing modes:
POINTING, FOCUS, and OTFMAP.  The OTF map must be set to be in the
(true-angle) horizontal system and the direction of the OTF subscans
must agree with that of the 2ndRotation.  (There is a special pako
script available in the bolometer pool to do this).

To avoid un-intentional errors, this feature can only be used by "privileged
users": ask the AOD or the NCS team.
```

7.15.8 SET TOPOLOGY

```
SET TOPOLOGY topology

topology   Character(len=24) ! Topology for the overlapping azimuth range

Choices for topology are:
LOW HIGH

Select a "topology" for sources in the overlapping azimuth range
60 to 100 degrees = 420 to 460 degrees.

The 30m antenna has azimuth limits of 60 and 460 degrees.  Azimuth 360
```

```
degrees is due North. Therefore there is an overlap range approximately
toward East-Northeast, which the antenna can reach at a low azimuth 60
to 100 (from the South) or at a high azimuth 420 to 460 (from the North).

SET TOPOLOGY LOW  selects to use the azimuth range  60 to 420 degrees
SET TOPOLOGY HIGH selects to use the azimuth range 100 to 460 degrees

Note: this is shown in a figure in paKo's manual,
Section "NCS Explained: Azimuth Topology".
```

7.15.9 SET EMIRCHECK

```
SET EMIRcheck emirCheck

emirCheck  Character         !

Choices for emirCheck are:

"strict"|"relaxed"|"loose"

Make the checking of frequency limits less than strict. This allows
to command frequencies that are completely outside the designed and
tested range of the receiver bands.

The standard and recommended limit checking corresponds to "strict".

THIS MUST BE USED CAREFULLY AND ONLY IN CONSULTATION WITH STAFF
ASTRONOMERS OR ENGINEERS.
```

7.15.10 SET LIMITCHECK

```
SET LIMITCHECK limitCheck

limitCheck  Character(len=24) !

Choices for limitCheck are:

"strict"|"relaxed"|"loose"

Make the checking of some limits less than strict.

The standard and recommended limit checking corresponds to "strict".

THIS MUST BE USED CAREFULLY AND ONLY IN CONSULTATION WITH STAFF
ASTRONOMERS OR ENGINEERS.
```

```
NB: this is a protected command (needs privilege).
```

7.15.11 SET USERLEVEL

```
SET USERLEVEL userLevel

userLevel  Character(len=24) !

Choices for userLevel are:

"beginner"|"normal"|"experienced"

Sets level of user's experience with paKo and the NCS.  Some features,
that require special care, are only available if userLevel is set to a
higher level.
```

7.15.12 SET EXAMPLES

```
!
! Id: demo-set.pako
!     basic SET EXAMPLES, v 1.1.1 2009-05-18 Hans Ungerechts
!
SIC PRIORITY 1 PAKO                         ! PAKO commands get precedence
!                                           ! over similar GREG commans!
!
SET Project   111-22                        ! project ID (project number)
SET PI       "Dr. Lilo D. Doe"              ! principal investigator
SET Observer "John Doe"                     !
SET Operator  Pako                          !
SET Topology  low                           ! topology for azimuth
!
SET Level     3  3                          ! suppress informational message
!                                           ! ("I-messages") from paKo
!
DEVICE image w                              ! for plots
!
SHOW                                        ! show the values set with set
!
!! NOTE: don't use special characters like <, >, &, accents in the names!
!!
!
! Id: demo-set2.pako
!     additional SET EXAMPLES, v 1.1.1 2009-05-08 Hans Ungerechts
!
!! SET doSubmit   YES                       ! to allow submission to Queue
!
SET Pointing   -1.1 2.2                     ! pointing corrections
SET Focus      -2.3                         ! focus correction      [mm]
```

```
!
SHOW                                        ! show the values set with set
!
```

7.16 SHOW

```
  SHOW

  List all parameters that can be set with command SET,
  as well as their current values.
```

7.17 SOURCE

```
SOURCE sourceName
       [[systemName epoch] lambda beta
          [referenceFrame velocity     ] ]
SOURCE Body sourceName
            perihelionEpoch ascendingNode      argumentOfPerihelion
            inclination     perihelionDistance eccentricity

Select a source from the source catalog or specify source parameters
directly on command the line.

Character*12  :: sourceName            ! don't use: & < > ( ) /
Character     :: systemName            !
[C]Real       :: epoch                 ! in units [years]
                                       ! NOTE: epoch should be J2000.0
Coordinate    :: lambda                ! longitude
Coordinate    :: beta                  ! latitude
Character     :: referenceFrame        ! reference system for velocity
Real          :: velocity              ! in units [km/s]

IMPORTANT NOTES:

sourceName is limited to 12 characters.

So far only Equatorial J2000.0 coordinates are well tested.
<<TBD:
Observations of the Sun and near the Sun are not yet supported.
>>


NB: Don't use / & < > in names of sources, lines, projects,
PI, observer, operator, etc. Don't use ()/ in source names.

IMPORTANT NOTE ON VELOCITY:
```

```
One should not use very large Doppler velocities (thousands  of  kilome-
ters)  to  achieve  red-shift  corrections  of  frequencies. Instead one
should enter the red-shifted frequencies in the line  catalog  (or  with
the RECEIVER command) and use Doppler velocity of 0.0.

The alternative approach (with very large Doppler velocities) needs spe-
cial methods and attention in the data processing, which are "*not*  im-
plemented  in  CLASS  because it is better to observe in such a way that
minimum modification to the data is done later on"  (J.  Pety).   For  a
full  discussion of this question see: Gordon et al. 1992, A&A, 264, 337
in Sect. 6



The second form accepts 6 Real arguments to specify the orbital
elements of a solar system body:
Body                                ! special keyword -- exactly like this!
Real       :: perihelionEpoch       ! Julian Date [d]
Real       :: ascendingNode         ! [deg]
Real       :: argumentOfPerihelion  ! [deg]
Real       :: inclination           ! [deg]
Real       :: perihelionDistance    ! [deg]
Real       :: eccentricity          !

If only sourceName is specified, we try to read the other parameters
from the source catalog specified with CATALOG SOURCE fileName. The
sourceName in the command must match a source name in the source
catalog with all characters (no minimum match), but the case is
ignored for the matching. Example: SOURCE w3oh matches W3OH in the
source catalog, but SOURCE w3o does not!

The option: /VELOCITY systemVelocity velocity overrides the values in
the catalog.

Epoch can optionally start with a 1-character code "J" or "B" to
distinguish between "J" and "B" epochs/ equatorial coordinates.  (If
this code letter is not present, "J" is implied!).

The coordinates are specified in astronomical sexagesimal format:
with : as field separator, i.e.:

 hh:mm:ss.ss
ddd:'':"".""

Examples:
 12:34:56.78 for  12 hours,   34 minutes,     56.78 seconds
123:45:67.89 for 123 degrees, 45 arc minutes, 67.89 arc seconds

For systemName: equatorial and haDec, the longitude, lambda, is
assumed to be in hours; for all other systems it is assumed to be in
degrees.  Latitude, beta, is always in degrees.

Choices for systemName:
"equatorial"
```

```
"horizontal"

<<TBD: not yet supported:   >>
<<TBD: "galactic"           >>
<<TBD: "apparentEquatorial" >>
<<TBD: "ecliptic"           >>
<<TBD: "apparentEcliptic"   >>
<<TBD: "haDec "             >>

Choices for referenceFrame:
"LSR"
"barycentric"
"heliocentric"

<<TBD: not yet supported:    >>
<<TBD: "3K"                  >>
<<TBD: "galactocentric"      >>
<<TBD: "body"                >>
<<TBD: "geocentric"          >>
<<TBD: "topocentric"         >>
<<TBD: "null"                >>

Planets' names are accepted as a special case, if sourceName is one of:
"Mercury"
"Venus"
"Mars"
"Jupiter"
"Saturn"
"Uranus"
"Neptune"
"Pluto"

Satellites' (moons') names are accepted, if sourceName is one of:
"Phobos"
"Deimos"
"Io"
"Europa"
"Ganymede"
"Callisto"
"Mimas"
"Enceladus"
"Tethys"
"Dione"
"Rhea"
"Titan"
"Hyperion"
"Iapetus"
"Miranda"
"Ariel"
"Umbriel"
"Titania"
"Oberon"
"Gabriel"
"Moon"
```

7.17.1 SOURCE /CATALOG

```
/CATALOG catalogName
/CATALOG *

Character :: catalogName

Allows to specify that the search (for a source) should be done
in the catalog file "catalogName", instead of the catalog specified
with command CATALOG.  The default file extension is .sou

/CATALOG *

Implies that the search will be done in the standard pointing
source catalog, iram-J2000.sou.
```

7.17.2 SOURCE /GREP

```
/GREP

Does a "grep" search for the (partial) source name or string in the
source catalog and lists any matching lines.  This search ignores the
case.  This is only to help the user search through a source catalog.
Even if the match is unique, the source found is not selected. (re-enter
the SOURCE command with the full source name!)
```

7.17.3 SOURCE /VELOCITY

```
/VELOCITY  referenceFrame velocity

Specify reference frame and source radial velocity

Character :: referenceFrame    ! reference system for velocity
Real      :: velocity          ! in units [km/s]

Choices for referenceFrame:
"LSR"
"barycentric"
"heliocentric"

<<TBD: not yet supported:    >>
<<TBD: "3K"                  >>
<<TBD: "galactocentric"      >>
<<TBD: "body"                >>
<<TBD: "geocentric"          >>
<<TBD: "topocentric"         >>
<<TBD: "null"                >>

IMPORTANT NOTE ON VELOCITY:
```

```
One should not use very large Doppler velocities (thousands of
kilometers) to achieve red-shift corrections of frequencies. Instead
one should enter the red-shifted frequencies in the line catalog (or
with the RECEIVER command) and use Doppler velocity of 0.0.

The alternative approach (with very large Doppler velocities) needs
special methods and attention in the data processing, which are "*not*
implemented in CLASS because it is better to observe in such a way
that minimum modification to the data is done later on" (J. Pety).
For a full discussion of this question see: Gordon et al. 1992, A&A,
264, 337 in Sect. 6
```

7.17.4 SOURCE EXAMPLES

```
!
! Id: demo-source.pako
!     basic SOURCE EXAMPLES,v 1.1.1 2009-05-08 by Hans Ungerechts
!
CATALOG SOURCE  demo.sou                ! select source catalog
!
SOURCE  NGC7027                         ! select source from catalog
!! OFFSETS /Clear                       ! optional: clear previously set off
!
PAUSE
!
!! OTHER WAYS TO SPECIFY A SOURCE:
!
SOURCE CALORI /catalog lines-J2000      ! select source from another catalog
PAUSE
!
SOURCE OCET EQ J2000 -
   02:19:20.71 -02:58:36.17 LSR 46.800  ! command-line specification of sour
PAUSE
!
SOURCE Mars                             ! planet Mars
PAUSE
!
SOURCE Moon                             ! our Moon
PAUSE
!
SOURCE Io                               ! Jupiter's satellite "Io"
PAUSE
!
SOURCE Body Pako -                      !
   2455000.0 22.2 33.3 44.4 55.5 0.66   ! solar system body (orbital element
PAUSE
!
SOURCE w3oh                             ! will match W3OH in demo.sou
!
!! NOTES: source names must match:
```

```
!!           full source name in catalog or
!!           full name of planet or satellite
!!        the case is ignored for source name matching
!
RETURN
!
```

7.18 START

```
START

Start an observation, i.e., translate its specification to XML
and submit it to the observing queue.

Observing jobs are sent to the observing queue only if the observer has
SET DOSUBMIT YES
in paKo (see command SET DOSUBMIT) and if the operator has selected
the current project to be the "current observing queue".

IMPORTANT NOTE: to avoid any possible confusion, in each project
account at the 30-m telescope, only 1 running instance of Pako should
have SET DOSUBMIT YES!

Example:

SOURCE ...
OTFMAP ...
START              ! will start and OTF map
```

7.19 SUBSCAN

```
SUBSCAN xOffset    yOffset
SUBSCAN xStart     yStart     xEnd       yEnd
SUBSCAN xAmplitude yAmplitude frequencyX frequencyY xCenter yCenter phiX phi

NB: this is a protected command (needs privilege).

Add to user-defined list of subscans and segments for observing mode "DIY";
compare command DIY. The subscan command has the 3 main variants above,
depending on the number of parameters:

2 --> Track subscan with fixed offsets
4 --> Linear OTF segment (subscan)
8 --> Lissajous OTF segment (subscan), IMPORTANT: SEE NOTE BELOW

Option /TYPE allows to enforce that the command is interpreted for one
```

```
the 3 different types, independant of the number of parameters.

Option /TUNE allows to specify that a Track subscan will be used to "tune"
an instrument, e.g., NIKA.

Real :: xOffset     ! x offset fixed-position TRACK subscan
Real :: yOffset     ! y offset fixed-position TRACK subscan

Real :: xStart      ! x offset start  of linear OTF  segment
Real :: yStart      ! y offset start  of linear OTF  segment
Real :: xEnd        ! x offset end    of linear OTF  segment
Real :: yEnd        ! y offset end    of linear OTF  segment

Real :: xAmplitude  ! x amplitude              Lissajous OTF segment
Real :: yAmplitude  ! y amplitude              Lissajous OTF segment
Real :: frequencyX  ! frequency    [Hz]  for x Lissajous OTF segment
Real :: frequencyY  ! frequency    [Hz]  for y Lissajous OTF segment
Real :: xCenter     ! x center                 Lissajous OTF segment
Real :: yCenter     ! y center                 Lissajous OTF segment
Real :: phiX        ! phase offset [rad] for x Lissajous OTF segment
Real :: phiY        ! phase offset [rad] for y Lissajous OTF segment

If an asterisk * appears in place of any parameter, the value will
remain unchanged from the last valid SUBSCAN command.

NOTES: pako will make its best effort to "guess" the values for
unspecified parameters based on the values of its internal variables
after the previous valid SUBSCAN command.
Each time a SUBSCAN is accepted without error message, a subscan is
added to the list; even if the command is only "SUBSCAN" by itself!
Be careful that a parameter in the command line can refer to different
variables depending on the type of the segment/subscan, e.g., the 1st
parameter can refer to xOffset, xStart, or xAmplitude.
These features should be used with special care, e.g., to experiment
with the DIYLIST and SUBSCAN commands.
It is recommended to collect all SUBSCAN commands in a paKo script and
explicitly specify all parameters for each subscan!

Before START of a DIY subscanlist, you can enter DIYLIST to review
pako's I-DIY messages listing the subscan currently defined (this
requires SET LEVEL 2 or lower), e.g.:
PAKO> set level 2
PAKO> diy
I-DIY,  segments #: 1 to 3
I-DIY,  1 track on at -400.0 -300.0 arcsec projection 10.0 s
I-DIY,  2 onTheFly -300.0 -200.0 to 330.0 220.0 arcsec projection 66.0 s
I-DIY,  3 track on at 440.0 330.0 arcsec projection 10.0 s


IMPORTANT: LISSAJOUS OTF

During a Lissajous OTF segment, the position offsets
x and y as a function of time t are:
```

```
x = xCenter + xAmplitude * SIN(2 Pi frequencyX t + phiX)
y = yCenter + yAmplitude * SIN(2 Pi frequencyY t + phiY)

SIN is the usual sine function, Pi is the number Pi.

xAmplitude yAmplitude xCenter yCenter are in angle units ([arc sec])
frequencyX frequencyY                 are in [Hz]
phiX       phiY                       are in [rad]

Note that the possible frequencies are very low,
typically 0.01 to 0.15 Hz.

At the start of a Lissajous subscan, paKo will insert a "ramp" along a
straight line, i.e., a linear OTF segment, increasing the count of
segments by 2.  This ramp up starts with speed 0 relative to the
source and joins smoothly with the start position and velocity of the
Lissajous segment.  The purpose is to avoid a sudden aceleration at
the start of the Lissajous segment.  Command DIY lists this inserted
OTF segment as well as the Lisssajous segment.  The inserted ramp up
segment and the Lissajous segment become part of the same subscan.

Lissajous curves with large amplitudes or frequencies can reach the
antenna's speed and acceleration limits for tracking.  Lissajous
curves can be executed only for elevations less than a maximum, which
depends on the Lissajous parameters.  For information, this elevation
condition is shown by pako. Even below the limits, during very fast
Lissajous curves the tracking errors will be higher, several arc sec,
than during most other observations.

DO NOT TRY TO OBSERVE LISSAJOUS ABOVE THIS MAXIMUM ELEVATION.
```

7.19.1 SUBSCAN /CROFLAG

```
/CROFLAG croCode

Character :: croCode    !   R = off-source Reference
                        !   O = On-source
```

7.19.2 SUBSCAN /RAMP

```
        /RAMP      "None"
        /RAMP      "Up"     [tRampUp]
<<TBD:  /RAMP      "Down"   [tRampDown]   ! not yet implemented >>

Real       :: tRamp         ! minimal time for ramp

/RAMP Up tRamp

/RAMP Up must be used for Lissajous subscans.
```

```
At the start of a Lissajous subscan, paKo will insert a "ramp" along a
straight line, i.e., a linear OTF segment, increasing the count of
segments by 2.  This ramp up starts with speed 0 relative to the
source and joins smoothly with the start position and velocity of the
Lissajous segment.  The purpose is to avoid a sudden aceleration at
the start of the Lissajous segment.  Command DIY lists this inserted
OTF segment as well as the Lisssajous segment.  The inserted ramp up
segment and the Lissajous segment become part of the same subscan.


Example:

SUBSCAN 100 200 0.01 0.02 -10 -20 0.1 0.2 /ramp up 9

Lissajous subscan with a ramp up of at least 9 [sec].
```

7.19.3 SUBSCAN /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor
1/cos(elevation) applied to the azimuth offset.  This is the system in
which OTF maps with Wobbler switching and the bolometer are normally
done.
```

7.19.4 SUBSCAN /TOTF

```
/TOTF tOtf

time per OTF subscan or segment

Real       :: tOtf             ! time

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

```
NOTE: this applies to linear and Lissajous OTF subscan segments
```

7.19.5 SUBSCAN /TSUBSCAN

```
/TSUBSCAN tSubscan

time per subscan

Real       :: tSubscan         ! time

NOTE: this applies to Track subscans
```

7.19.6 SUBSCAN /TUNE

```
/TUNE [yes|no]

Logical   :: doTune

"Tune" an instrument, e.g., NIKA.

NOTE: this applies to Track subscans. If  a  valid  specification  of  a
TRACK subscan is entered without the option /TUNE, "no" is implied.
```

7.19.7 SUBSCAN /TYPE

```
/TYPE Type

Specify segment or subscan type.

Character :: Type                ! one of:
                                 ! TRACK
                                 ! LINEAR
                                 ! LISSAJOUS
```

7.20 SWBEAM

```
SWBEAM (no parameters)

Select beam switching, i.e., switching between 2 positions on the sky
using the rotating beam-switch chopper wheel. This mode is usually
only used for POINTING and FOCUS with the heterodyne receivers.
```

7.21 SWFREQUENCY

```
SWFREQUENCY fOffset1 [fOffset2]

Select and set up frequency switching (FS).

Real      :: fOffset1          ! 1st frequency offset [MHz]
Real      :: fOffset2          ! 2nd frequency offset [MHz]

fOffset2 should be set to be = -fOffset1 (symmetric FS).
This is done by default, if only fOffset1 is specified.
(Note that then ABS(fOffset1) = FS amplitude = 1/2 FS throw).
FS  with fOffset2 not equal -fOffset1 is experimental.

/RECEIVER allows to set fOffset1 and fOffset2 for each connected
receiver differently.

Parameters of other options are always the same for all receivers.

Limits for fOffset1 and fOffset2 are:

  -9 to  +9   with the 3 mm receivers /bands
 -18 to +18   with the 2 mm receivers /bands
 -27 to +27   with the 1 mm receivers /bands


IMPORTANT NOTES about use of Frequency Switching (FS)

Frequency Switching (FS) can be very powerful and efficient for some
projects, e. g., mapping of narrow spectral lines in cold dark clouds
outside the plane of the Milky Way.  However, before deciding to use
frequency switching one should consider some potential drawbacks:

The target lines should be narrow enough so that line signals from the
2 phases of the switching cycle are well separated.

The spectral baseline will generally be less flat than in other
switching modes.

Some spectral lines are also emitted in the earth's mesosphere, e.g.,
the mesopheric lines from (12)CO are rather strong, typically several
[K], and they will be seen in FS spectra taken toward astronomical
sources with a low Doppler shift. The mesospheric lines will appear at
a frequency and velocity that correspond to the rest frame of the
athmosphere, i. e., to good approximation, the observatory.  If,
e. g., you observe using Doppler corrections for the LSR scale, the
mesospheric lines will appear in the spectra at -1 * the velocity of
the Local Standard of Rest relative to the observatory.

Care must be taken that mesospheric lines are not confused with the
lines from the astronomical source, which will appear in the spectrum
at the velocity of the source relative to the LSR.  The ASTRO software
can calculate the velocity of the LSR relative to the observatory for
any source and time.  During observations, this velocity is also
displayed on one of the NCS monitoring windows.
```

```
When observing sources near the plane of the Milky Way, line emission
from clouds at other velocities than the target source, e. g., other
spiral arms, can cause confusion.

In case of any doubt, there is a special report on FS that gives more
advice!
```

7.21.1 SWFREQUENCY /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.21.2 SWFREQUENCY /RECEIVER

```
/RECEIVER receiverBand

Character :: receiverBand   ! receiver / EMIR band

Choices for receiverBand are:
E090 E150 E230 E330 HERA1 HERA2
```

7.21.3 SWFREQUENCY /TPHASE

```
/TPHASE tPhase

time per switching PHASE

Real       :: tPhase          ! time
```

7.21.4 SWFREQUENCY EXAMPLES

```
!
! SWFREQUENCY EXAMPLES, v1.1 2009-05-11 Hans Ungerechts
!
SWFREQUENCY                   /default      ! Defaults
!
SWFREQUENCY   -3.8     3.8                  ! for all receiver bands
!
SWFREQUENCY   -3.9     3.9  /receiver E090  !  for EMIR band E090
SWFREQUENCY  -11.7    11.7  /receiver E230  !  for EMIR band E230
SWFREQUENCY                 /tphase   0.20  !  same for all receivers/bands
!
!                                           !  setup frequency switching
SWFREQUENCY   -3.7          /receiver E090  !  fOffset2 will be   +3.7
SWFREQUENCY  -11.6          /receiver E230  !  fOffset2 will be  +11.6
!
```

7.22 SWTOTAL

```
SWTOTAL  (no parameters)

Select total power, i.e., neither beam, frequency, nor wobbler
switching. Typically used with OTFMAP with off-source references or
ONOFF "position switching".
```

7.22.1 SWTOTAL /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.22.2 SWTOTAL /TPHASE

```
/TPHASE tPhase

time per switching PHASE

Real       :: tPhase          ! time
```

7.23 SWWOBBLER

```
SWWOBBLER wOffset1 [wOffset2]

Select and set up wobbler switching using the wobbling secondary
mirror to switch between 2 positions on the sky.  This is typically
used with the observing modes POINTING, FOCUS, ONOFF, or --with the
bolometer-- OTFMAP.

Real      :: wOffset1          ! 1st wobbler offset (1/2 "throw")
Real      :: wOffset2          ! 2nd wobbler offset = -wOffset1

IMPORTANT NOTE: Observers must inform the operator if they want to use
this feature.

There is a relation between the maximum allowed Wobbler throw and the
minimum time per phase: for large throws the switching must be slow,
i.e., time per phase must be large.  For /timePhase 1 [sec] or longer,
any wobbler throw is allowed up to the maximum of 240 ["].
```

```
Posssible combinations are, e. g.:

wOffset1   throw  timePhase
   -22"      44"    0.25 sec
   -22"      44"    1.0  sec
  -120"     240"    1.0  sec
  -120"     240"    2.0  sec

Note that for OTFMAPs with Wobbler switching, special restoration
algorithms are needed to recover an image of the source brightness
distribution. These are available, e. g., in the MOPSIC software.


If SWWOBBLER and ONOFF are combined in the standard way, we
effectively take data at 3 positions:

1. the source position
2. the source position + throw  (offset in the "true-angle" horizontal syste
3. the source position - throw  (offset in the "true-angle" horizontal syste

with throw = ABS(wOffset2-wOffset1).

Data from 1. are treated as source signal, data from 2 and 3 as
off-source reference signal.  Note that in the astronomical
coordinates, positions 2 and 3 will rotate around the source position
(1).  Therefore one must normally be sure that the extent of the source
is less than throw-beamWidth (/2).
```

7.23.1 SWWOBBLER /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.23.2 SWWOBBLER /TPHASE

```
/TPHASE tPhase

time per switching PHASE

Real       :: tPhase          ! time
```

7.24 TIP

```
TIP [azimuth]
```

```
Specify an antenna tipping (a.k.a., "skydip").

Real      :: azimuth           ! azimuth of tip

If azimuth is not specified, the current azimuth of the telescope is
used.

NOTE:
TIP is always and automatically done with switching mode "total power"
and for bolometer observations the time per phase is fixed at 0.5 [sec]
```

7.24.1 TIP /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.24.2 TIP /AIRMASS

```
/AIRMASS airmassStart [TO] airmassEnd [BY] airmassStep

range of airmass for TIP.

Real      :: airmassStart      !
Real      :: airmassEnd        !
Real      :: airmassStep       !

NOTE 1: elevation = ASIN(1/airmass)

NOTE 2: for slew-tips, TIP /SLEW:
        airmassStep has no effect
        airmassStart > airmassEnd is allowed; this implies:
        elevation (at start) < elevation (at end), i.e.,
        TIP from low to high elevation.

        (for "traditional" TIP with /SLEW no, airmassStart < airmassEnd,
        i.e., they go from high to low elevation.)
```

7.24.3 TIP /TSUBSCAN

```
/TSUBSCAN tSubscan

time per subscan

Real       :: tSubscan         ! time
```

7.25 TRACK

```
TRACK xOffset yOffset

specify tracking of a single position

Real      :: xOffset           ! x-offset of "on-source" position
Real      :: yOffset           ! y-offset of "on-source" position

NOTES:
TRACK is normally used for observations with frequency switching
(SWFREQUENCY); also for some special observations, e.g., of pulsars.
There is a built-in limit to the time per subscan, currently (2006-07)
it is 3600 seconds (1 hour).  If for special purposes one needs to
track a source for a longer time, this can easily be done by using
several subscans.
```

7.25.1 TRACK /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.25.2 TRACK /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
```

```
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth


   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
   the values xOffset yOffset are used during the observations.
   (this inludes the case that they are explicitly set to 0.0).
   It is up to the observer to make sure that they are "correct".
   (in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

   If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
   (cleared), for the MAMBO bolometer, Nasmyth offsets are used
   automatically according to the selected bolometer channel (pixel).
```

7.25.3 TRACK /NSUBSCANS

```
/NSUBSCANS nSubscans

Integer   :: nSubscans         ! number of subscans
```

7.25.4 TRACK /TSUBSCAN

```
/TSUBSCAN tSubscan

time per subscan

Real       :: tSubscan         ! time
```

7.25.5 TRACK EXAMPLES

```
!
! Id: demo-track.pako
!     TRACK EXAMPLE,v 1.1.11 2011-11-25 Hans Ungerechts
!
@ demo-rx                                  !  demo setup of receivers
!
BACKEND /CLEAR                             !  clear previous backends
BACKEND VESPA 1 0.040 40.0 0.0 E090 hor LI  !  high spectral resolution
BACKEND VESPA 2 0.040 40.0 0.0 E090 ver LI  !  with VESPA
```

```
BACKEND VESPA 3 0.080 80.0 0.0 E230 hor LI
BACKEND VESPA 4 0.080 80.0 0.0 E230 ver LI
!                                          !  REPLACE WITH YOUR SETUP!
!
SET ANGLE arcsec                           !
!
!                                          !  setup frequency switching
SWFREQUENCY   -3.9     3.9  /receiver E090  !  for EMIR band E090
SWFREQUENCY  -11.7    11.7  /receiver E230  !  for EMIR band E230
SWFREQUENCY                 /tphase   0.20  !  same for all receivers/bands
!
CALIBRATE                                - !
  /AMBIENT                               - !  ambient load
  /COLD                                  - !  cold    load
  /SKY       -600.0   0.0                - !  sky at offsets -600.0 0.0
  /SYSTEM       projection               - !  system for SKY offsets
  /TCALIBRATE   5.0                        !  time per calibration subscan
!
PAUSE "CALIBRATE OK to start? [c/q]"       !  a chance to check
!
START                                      !  start
!
TRACK           40.0   -30.0           -   !  offsets of on position
  /NSUBSCANS    5                      -   !  number of subscans
  /SYSTEM       projection             -   !  system for offset
  /TSUBSCAN     60                          !  time per subscan
!
PAUSE "TRACK SWFREQUENCY OK to start? [c/q]" !  a chance to check
!
START                                      !  start
!
!! Comments:
!! we assume here that the source already has been selected,
!! see: demo-source
```

7.26 VLBI

```
VLBI

Track a single position for VLBI.

This observing mode must not be used for other (non-VLBI) observations.

Some special behaviours are asscociated with the observing mode VLBI:
 - The scan has only one subscan on the (fixed) source position.
 - This subscan will be executed for up to 1 hour.
   In practice it is ended, when the START command is executed for the
   next observation, e.g., when a new VLBI scan, or a POINTING or FOCUS
```

```
   is started.
 - Normally, the VLBI field system sends the commands
   SOURCE ...
   VLBI
   START
   directly to paKo, which is running in a special terminal window.  The
   field system sends these commands for the next scan (immediately)
   after the VLBI data recording for the current VLBI target source
   (for the currant scan) is finished.
```

7.27 OPTIONS

```
SUMMARY OF OPTIONS FOR PAKO\ COMMANDS:

(For help on commands say HELP PAKO\ )

For details say, e.g.,  HELP OPTIONS /CROLOOP
                   or:  HELP OP      /CRO

To see if a command has a particular option, see the end of the
HELP for this command.
```

7.27.1 OPTIONS /AIRMASS

```
/AIRMASS airmassStart [TO] airmassEnd [BY] airmassStep

range of airmass for TIP.

Real      :: airmassStart      !
Real      :: airmassEnd        !
Real      :: airmassStep       !

NOTE 1: elevation = ASIN(1/airmass)

NOTE 2: for slew-tips, TIP /SLEW:
        airmassStep has no effect
        airmassStart > airmassEnd is allowed; this implies:
        elevation (at start) < elevation (at end), i.e.,
        TIP from low to high elevation.

        (for "traditional" TIP with /SLEW no, airmassStart < airmassEnd,
        i.e., they go from high to low elevation.)
```

7.27.2 OPTIONS /AMBIENT

```
/AMBIENT [yes|no]

Do a calibration subscan on the ambient temperature load.
```

```
Logical   :: doAmbient        ! default: true
```

7.27.3 OPTIONS /APPEND

```
/APPEND [yes|no]

Append to existing file, do not create a new one.

Logical   :: doAppend        ! default: false
```

7.27.4 OPTIONS /CLEAR

```
/CLEAR  [yes|no]

Completely clear a list of connected hardware, e.g., receivers, backends,
or parameters of the associated command.
```

7.27.5 OPTIONS /COLD

```
/COLD [yes|no]

Do a calibration subscan on the cold temperature load.

Logical   :: doCold           ! default: true
```

7.27.6 OPTIONS /CONNECT

```
/CONNECT [yes|no]

connect (or disconnect) the specified hardware, e.g.,
backend or backend part.
```

7.27.7 OPTIONS /CROLOOP

```
/CROLOOP croLoop

sequence of R = off-source Reference
            O = On-source subscans

Character :: croLoop

Example:
/croLoop ROOR
```

7.27.8 OPTIONS /DEFAULTS

```
/DEFAULTS  [yes|no]

Restore default values for all parameters and options.
```

7.27.9 OPTIONS /DEROTATOR

```
/DEROTATOR angle system

Specify derotator angle for HERA

Real      :: angle             ! in units [deg] (!)
Character :: system            !

Choices for system:
"Nasmyth"
"horizon"
"equatorial"
"frame"                        ! same as Nasmyth
"sky"                          ! same as equatorial

NOTES: The last 2 are for consistency with old control system and HERA conve
This option works only for RECEIVER HERA1 or RECEIVER HERA2 (of course it's
same angle for HERA1 and HERA2).
```

7.27.10 OPTIONS /DISCONNECT

```
/DISCONNECT

disconnect the specified hardware, e.g.,
backend or backend part.
```

7.27.11 OPTIONS /DOPPLER

```
/DOPPLER doppler

Character :: doppler           ! apply doppler correction?
                               ! choices: DOPPLER|FIXED
```

7.27.12 OPTIONS /DOUBLEBEAM

```
/DOUBLEBEAM [yes|no]

Pointing: do a "double-beam" pointing

Logical    :: doDoubleBeam

This is valid only for pointing with Wobbler switching (SWWOBBLER).

This option has an effect only if SET 2nRotation 0.0
```

7.27.13 OPTIONS /EFFICIENCY

```
/EFFICIENCY forwardEfficiency beamEfficiency

specify forward and beam efficiencies

Real      :: forwardEfficiency !
Real      :: beamEfficiency    !
```

7.27.14 OPTIONS /FILE

```
/FILE fileName

Specify file name.

Character :: fileName          !
```

7.27.15 OPTIONS /FINE

```
/FINE

for BACKEND FTS select the "fine" mode with a resolution of ~ 0.049 [MHz]

Note: with the option /DEFAULT or the short syntax, this allows to
select the fine resolution without explicitly entering the values of
resolution and bandwidth.
```

7.27.16 OPTIONS /FOCUS

```
/FOCUS f1 f2 [... f18] [direction]
or
/FOCUS NO

[For Lissajous] designate the purpose of the scan to be "Focus", i.e.,
to determine focus corrections.  A subscan with a Lissajous curve will
be executed for each focus offset specified.

Real      :: f1 f2 [... f18]   ! focus offsets [mm]
                               ! (at least 2, at most 18 values)
Character :: direction         ! direction of focus offsets, one of:
                               ! X
                               ! Y
                               ! Z

/FOCUS NO clears the option /FOCUS.
```

7.27.17 OPTIONS /GAINIMAGE

```
/GAINIMAGE gainImage [dB]

Specify the gain ratio of image to signal sidebands.

Real      :: gainImage         !

If "dB" is added after the value, the ratio is assumed to be in dB,
otherwise a decimal fraction.

Simple standard values for these gain ratios can be found on the IRAM
30-m web pages (Telescope Summary). If you need accurate values for the
single-pixel heterodyne receivers, you should measure them with:
CALIBRATE /GAINIMAGE receiverName
```

7.27.18 OPTIONS /GREP

```
/GREP

Does a "grep" search for the (partial) source name or string in the
source catalog and lists any matching lines.  This search ignores the
case.  This is only to help the user search through a source catalog.
Even if the match is unique, the source found is not selected. (re-enter
the SOURCE command with the full source name!)
```

7.27.19 OPTIONS /GRID

```
/GRID [yes|no]

Do a calibration subscan on a grid in front of the cold temperature load.
This is a special calibration option for polarization observations.

Logical   :: doGrid           ! default: true

IMPORTANT NOTE:
remember to turn this option off again for normal calibrations:
e.g., CALIBRATE /GRID NO or CALIBRATE /DEFAULT.
```

7.27.20 OPTIONS /HORIZONTAL

```
/HORIZONTAL [sb1 [sb2]]
/HORIZONTAL n[one]

EMIR subbands for Horizontal polarization.


This option applies only to EMIR.

Character   :: sb1, sb2   ! for EMIR: LO|LI|UI|UO

This option selects which EMIR subband(s) of this polarization will be
```

```
transmitted through IF cables 1 to 4.  Note that some backends, NBC,
4MHz, WILMA, VESPA, can only be connected to IF cables 1 to 4, i.e.,
only to the EMIR subbands selected with the RECEIVER command.

For each EMIR band and polarization, at most 2 subbands can be
transmitted through IF cables 1 to 4.  Which combinations of EMIR
bands, polarizations, and subbands are possibble is determined by the
hardware of the EMIR IF switching box.  See the EMIR documentation for
details.

If no subband is explicitly specified with this option, paKo will
assume that for this polarization the same single subband SB is
requested as specified for the main parameters (frequency, tuning) of
the RECEIVER command for this EMIR band.


/HORIZONTAL n[one] means that from this polarization no subband
will be transported through IF cables 1 to 4.
```

7.27.21 OPTIONS /MODE

```
/MODE mode

Character :: mode                ! backend mode

Choices for mode are:
SIMPLE                           ! simple (standard)
PARALLEL                         ! parallel mode
POLARIZATION                     ! polarimetry

Select special mode for VESPA.
See VESPA user's guide for details.

For EMIR, /MODE PARALLEL or /MODE POLARIZATION connect VESPA
to the same band and subband in both polarizations; they must
previously have been selected with the RECEIVER command. For
exmples, see:
HELP BACKEND Examples
```

7.27.22 OPTIONS /NOTF

```
/NOTF nOtf

Integer   :: nOtf              ! number of OTF (on-the-fly) subscans
```

7.27.23 OPTIONS /NSUBSCANS

```
/NSUBSCANS nSubscans

Integer   :: nSubscans         ! number of subscans
```

7.27.24 OPTIONS /PERCENTAGE

```
/PERCENTAGE percentage

Real :: percentage  !  percentage of bandwidth to use

This is a special option for the autocorrelators, VESPA and WILMA.

For autocorrelators normally some channels at both ends of the band
are blanked because they do not contain usable data, and only the
central 'percentage' of the "theoretical" bandwidth is used, typically
about 90%.  Reasonable conservative defaults are automatically
applied: in general 90%, but 82% for VESPA with bandwidth 640.  This
option allows the observer to adjust the percentage for special
purposes.

For WILMA connected to EMIR, the useful bandwidth is 3720 MHz,
and counted as 100%.

See VESPA user's guide for details.
```

7.27.25 OPTIONS /POINTING

```
/POINTING [YES|NO]

Logical   :: doPointing      ! default: no

[For Lissajous] designate the purpose of the scan to be "Pointing",
i.e., to determine pointing corrections.

/POINTING NO clears the option /POINTING.
```

7.27.26 OPTIONS /RECEIVER

```
/RECEIVER receiverBand

Character :: receiverBand   ! receiver / EMIR band

Choices for receiverBand are:
E090 E150 E230 E330 HERA1 HERA2
```

7.27.27 OPTIONS /REFERENCE

```
/REFERENCE xOffsetR yOffsetR [systemNameRef]
or
/REFERENCE NO                  ! no reference

position of off-source reference subscans

Real      :: xOffsetR          ! x-offset
```

```
Real      :: yOffsetR          ! y-offset
Character :: systemNameRef     ! name of system
                               ! see /SYSTEM for choices

NOTE: with the usage /REFERENCE xOffsetR yOffsetR, both parameters are requi
but you can replace either parameter with * to leave it unchanged.
```

7.27.28 OPTIONS /SCALE

```
/SCALE scale

Select the calibration intensity scale.

Character :: scale             ! choices: ANTENNA|BEAM

If scale is "ANTENNA", the scale is antenna temperature.
If scale is "BEAM", the scale is (main) beam temperature.
```

7.27.29 OPTIONS /SKY

```
/SKY xOffsetC yOffsetC
or
/SKY NO                        ! do not do sky calibration

Do a calibration subscan on sky.

Real      :: xOffsetC          ! x-offset
Real      :: yOffsetC          ! y-offset

NOTES: with the usage /SKY xOffsetC yOffsetC, both parameters are required,
but you can replace either parameter with * to leave it unchanged.
The system for the offsets is selected through the option /SYSTEM.
```

7.27.30 OPTIONS /SPEED

```
/SPEED speed1 [speed2]

speed of OTF subscans

Real      :: speed1            ! speed at start
Real      :: speed2            ! speed at end

For OTFMAP speed2 = speed1.

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

7.27.31 OPTIONS /STEP

```
/STEP dx dy

Step (shift or translation)  between lines in a map.

Real      :: dx                ! shift in x-offsets
Real      :: dy                ! shift in y-offsets
```

7.27.32 OPTIONS /SWWOBBLER

```
/SWWOBBLER [yes|no]

(option of command ONOFF)

set parameters appropriate for on-off Wobbler switching

Logical   :: doSwWobbler

If switching mode SWWOBBLER has been selected, the following parameters
of ONOFF are set according to wOffset1 and wOffset2:

ONOFF
      xOffset        is set to: -wOffset1
      yOffset        is set to:  0.0

/REFERENCE           is set to:  Yes
      xOffsetR       is set to: -wOffset2
      yOffsetR       is set to:  0.0
      systemNameRef  is set to:  TRUEHORIZON

/SYSTEM
      systemName     is set to:  TRUEHORIZON

NOTE: in this case the values selected by /SWWOBBLER overrule the
corresponding values specified directly in the command.

NOTE: To do ONOFF with Wobbler switching and other (unconventional)
values for the parameters listed above, simply specify the values
using command ONOFF with option /SWWOBBLER NO (not recommended).

NOTE: If the selected switching mode is SWWOBBLER and if the option
/SWWOBBLER is no explicitly given, it will be assumed to be .True. (Yes),
If the selected switching mode is not SWWOBBLER and if the option
/SWWOBBLER is no explicitly given, it will be assumed to be .False. (No),
```

7.27.33 OPTIONS /SYMMETRIC

```
/SYMMETRIC [yes|no]

Logical   :: doSymmetric      ! default: no

(For ONOFF) select a subscan sequence that is "symmetric" in time.
```

```
This requires that the number of subscans is a multiple of 4.

Example for ONOFF with /SYMMETRIC no     /SYMMETRIC yes
1st subscan:                       OFF               OFF
2nd  "                             ON                ON
3rd  "                             OFF               ON
4th  "                             ON                OFF
(and so on)

NOTE that this does not in anyway change the positions
of the ON-source and OFF-source subscans!
```

7.27.34 OPTIONS /SYSTEM

```
/SYSTEM systemName

Name of system for offsets.

Character :: systemName          ! name of system, one of:
                                 ! PROJECTION
                                 ! TRUEHORIZON
                                 ! NASMYTH

<<TBD:                           ! DESCRIPTIVE>>
<<TBD:                           ! BASIS>>
<<TBD:                           ! EQUATORIAL>>
<<TBD:                           ! HADECL>>
<<TBD:                           ! HORIZONTAL>>

PROJECTION for now means only the standard simple "radio" projection
offsets in the chosen coordinate system. This is normally the
astronomical system of offsets in which point-by-point (TRACK, ONOFF)
or on-the-fly (OTFMAP) maps are made.

TRUEHORIZON means the horizontal system with a factor 1/cos(elevation)
applied to the azimuth offset.

NASMYTH are special offsets to point an off-center pixel of a
focal-plane array receiver (bolometer, HERA) to the commanded
astronomical position, e.g., to use an off-center pixel for pointing,
focus, ONOFF.

IMPORTANT NOTE: projection, trueHorizon

   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM projection,
   OFFSETS ... /SYSTEM projection is ignored (not used).
   If the observing mode (LISSAJOUS, ONOFF, OTFMAP, ...)
   is in /SYSTEM trueHorizon,
   OFFSETS ... /SYSTEM trueHorizon is ignored (not used).

IMPORTANT NOTE: OFFSETS   /SYSTEM Nasmyth
```

```
If OFFSETS xOffset yOffset /SYSTEM Nasmyth are specified in pako,
the values xOffset yOffset are used during the observations.
(this inludes the case that they are explicitly set to 0.0).
It is up to the observer to make sure that they are "correct".
(in pakoDisplay /SYS Nasmyth will be highlighted as yellow alert.)

If OFFSETS xOffset yOffset /SYSTEM Nasmyth are not specified
(cleared), for the MAMBO bolometer, Nasmyth offsets are used
automatically according to the selected bolometer channel (pixel).
```

7.27.35 OPTIONS /TCALIBRATE

```
/TCALIBRATE tCalibrate

Time per CALIBRATE subscan.

Real       :: tCalibrate       ! time
```

7.27.36 OPTIONS /TOTF

```
/TOTF tOtf

time per OTF subscan or segment

Real       :: tOtf             ! time

In commands like OTFMAP that have options /SPEED and /TOTF, either
option /SPEED or /TOTF can be used, the values of the other option are
then implied!
```

7.27.37 OPTIONS /TPHASE

```
/TPHASE tPhase

time per switching PHASE

Real       :: tPhase          ! time
```

7.27.38 OPTIONS /TREFERENCE

```
/TREFERENCE tReference

time per off-source reference

Real       :: tReference       ! time
```

7.27.39 OPTIONS /TSUBSCAN

```
/TSUBSCAN tSubscan
```

```
time per subscan

Real       :: tSubscan         ! time
```

7.27.40 OPTIONS /TEMPLOAD

```
/TEMPLOAD tempColdLoad tempAmbientLoad
/TEMPLOAD L[OOKUP]     L[OOKUP]
/TEMPLOAD *            ...

Set effective temperatures for the calibration loads at cold and ambient
temperature.

Real      :: tempColdLoad      !
Real      :: tempAmbientLoad   !

NEW LOGIC FOR SINGLE-PIXEL SIS RECEIVERS (FROM SUMMER 2007, paKo v1.0.7)

If a numerical value is entered for tempColdLoad or tempAmbientLoad,
that value is used for calibration calculations.

Instead of specifying a value one may enter the string L(OOKUP) for
tempColdLoad and/or tempAmbientLoad.  This is shown in the pakoDisplay
by the letter "L" instead of a number.

In this case, during the execution of the observations, the NCS will
use the "best-known" values for the corresponding load temperature(s).
For tempColdLoad this is based on a lookup table, for tempAmbientLoad
it is derived from a measurement of the physical temperature.

The lookup table for tempColdLoad normally is valid for the standard
calibration system with a closed-cycle cooling system.

A * can be substituted for tempColdLoad, which means to leave the
value for tempColdLoad unchanged from the previous RECEIVER command.

IF THE OBSERVERS HAVE ANY DOUBT ABOUT THIS, THEY SHOULD ASK A RECEIVER
ENGINEER FOR THE CORRECT VALUE AND ENTER IT EXPLICITLY.


NOTE: FOR HERA The new logic is not yet available. However, for HERA
"best-known" values are always used during the execution of the
observations. This is the same logic as in pevious versions of paKo/NCS.
```

7.27.41 OPTIONS /TUNE

```
/TUNE xOffsetT yOffsetT
or
/TUNE NO                  ! no tune subscan
```

```
Tune subscan at the specified offsets, before any other subscans.

Real      :: xOffsetT          ! x-offset for tune subscan
Real      :: yOffsetT          ! y-offset for tune subscan

NOTE: with the usage /TUNE xOffsetT yOffsetT, both parameters are required,
but you can replace either parameter with * to leave it unchanged.
```

7.27.42 OPTIONS /TTUNE

```
/TTUNE tTune

time per TUNE subscan

Real       :: tTune             ! time
```

7.27.43 OPTIONS /VELOCITY

```
/VELOCITY  referenceFrame velocity

Specify reference frame and source radial velocity

Character :: referenceFrame    ! reference system for velocity
Real      :: velocity          ! in units [km/s]

Choices for referenceFrame:
"LSR"
"barycentric"
"heliocentric"

<<TBD: not yet supported:    >>
<<TBD: "3K"                  >>
<<TBD: "galactocentric"      >>
<<TBD: "body"                >>
<<TBD: "geocentric"          >>
<<TBD: "topocentric"         >>
<<TBD: "null"                >>

IMPORTANT NOTE ON VELOCITY:

One should not use very large Doppler velocities (thousands of
kilometers) to achieve red-shift corrections of frequencies. Instead
one should enter the red-shifted frequencies in the line catalog (or
with the RECEIVER command) and use Doppler velocity of 0.0.

The alternative approach (with very large Doppler velocities) needs
special methods and attention in the data processing, which are "*not*
implemented in CLASS because it is better to observe in such a way
that minimum modification to the data is done later on" (J. Pety).
For a full discussion of this question see: Gordon et al. 1992, A&A,
264, 337 in Sect. 6
```

7.27.44 OPTIONS /VERTICAL

```
/VERTICAL [sb1 [sb2]]
/VERTICAL n[one]

EMIR subbands for Vertical polarization


This option applies only to EMIR.

Character   :: sb1, sb2   ! for EMIR: LO|LI|UI|UO

This option selects which EMIR subband(s) of this polarization will be
transmitted through IF cables 1 to 4.  Note that some backends, NBC,
4MHz, WILMA, VESPA, can only be connected to IF cables 1 to 4, i.e.,
only to the EMIR subbands selected with the RECEIVER command.

For each EMIR band and polarization, at most 2 subbands can be
transmitted through IF cables 1 to 4.  Which combinations of EMIR
bands, polarizations, and subbands are possibble is determined by the
hardware of the EMIR IF switching box.  See the EMIR documentation for
details.

If no subband is explicitly specified with this option, paKo will
assume that for this polarization the same single subband SB is
requested as specified for the main parameters (frequency, tuning) of
the RECEIVER command for this EMIR band.


/VERTICAL n[one] means that from this polarization no subband
will be transported through IF cables 1 to 4.
```

7.27.45 OPTIONS /WIDTH

```
/WIDTH width

Select receiver setup for WIDE or NARROW bandwidth mode.

Character :: width             ! width. choices: WIDE|NARROW

NOTE: Option /WIDTH NARROW changes the (local oscillator) setup of
receivers HERA1 and HERA2 in such a way
that a line in the center of the receiver bandwidth appears in the
center of the bands of the Backends 1MHz (with 256 or 512 MHz
bandwidth) and VESPA.

Spectrometers with 1GHz bandwidth normally require /WIDTH WIDE.
```

7.27.46 OPTIONS /ZIGZAG

```
/ZIGZAG [yes|no]

alternate direction between lines in a map

Logical    :: doZigzag
```

8 Postscript

"You will certainly not doubt the necessity of studying astronomy and physics,
if you are desirous of comprehending the relation between the world and Providence as it is in reality,
and not according to imagination."

"You must, however, not expect that everything our Sages say
respecting astronomical matters should agree with observation."

"Astronomy had, in the days of Aristotle,
not yet developed to the height it has reached at present."

Moses Maimonides — Moses ben Maimun — Abu Amran Musa
Cordoba, 1135—Cairo, 1204

From the Arabic "Dalalat al'Haírîn",
translated into Hebrew as "Moreh Nebûkîm" (1204),
and into Latin as "Doctor Perplexorum", "Dux Dubitantium".
French translation entitled "Guide des égarés" (Paris, 1856-66).
Here quoted from the English translation "The Guide of the Perplexed" (London, 1889).

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