Small Guide for Observations with the IRAM 30m Telescope

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1 Introduction

This "small guide for observations" is aimed to be used by the absolute beginners without any knowledge of the 30m telescope. Here, we will give you a review of a few commands. Just type "HELP *command*" in any of the softwares to get more information if you want to go further. In any case, ask the astronomer on duty, the operator or the receiver engineer if you have any problems. Good luck.

2 Before starting your observations

To define an observing strategy you dispose of several tools, among them:

- **A time estimator**: it can be found on our web site[1]. It asks you for the backends and frontends settings and your observation mode and gives the integration time necessary to reach a certain rms.
- **ASTRO**: with this software you can get Az-El plots and observability charts of your sources. It will help you in defining whenever it is convenient to observe your sources.

But first of course, you have to define a source catalogue and perhaps also a line catalogue:

1. Log on one of the HP workstation or Linux PC of the observers office. Your login name is as the following: "v_xxx_xx" (e.g: v_089_99). Ask the operator or the astronomer on duty for the password.
2. Do a telnet to the VAX IRAMEF (used for the data reduction), with the same login name and password.
3. There are example files of the source and line catalogue: "MODEL.CAT" and "MODEL.LIN". Make a copy of these files:

   ⟶ COPY MODEL.CAT YOUR_SOURCES.CAT
   ⟶ COPY MODEL.LIN YOUR_LINES.LIN

[1] **http://www.iram.es**

4. Edit your files following the exact formats:

   ⟶ EDIT /EDT YOUR_SOURCES.CAT
   ⟶ EDIT /EDT YOUR_LINES.LIN
   ⟶ "control z" and "EXIT" to exit from EDIT (QUIT to exit without saving)

   see the 30m manual v2.0 page 21 for more information on the source catalogue (choice of a coordinates system, etc ...)

5. If you want to produce visibility plots of your sources, you can enter in ASTRO:
   first:

   ⟶ EXPORT DISPLAY=*terminal_name*:0

   - *terminal_name*: e.g: mrt-lx7 for the OBS terminal

   ⟶ ASTRO

   In ASTRO:

   ⟶ ASTRO> CATALOG YOUR_SOURCES.CAT /VELETA
   ⟶ ASTRO> CATALOG YOUR_SOURCES.SOU

   the first command line is only needed to create the YOUR_SOURCES.SOU *file. Once it is done, just type the second command line when you enter in* ASTRO. *The extension* .SOU *is not necessary*

   ⟶ ASTRO> TIME *ut_time date*

   - *example*: TIME 23:59:99.999 31-DEC-1999 *(respect strictly this format)*

   ⟶ ASTRO> SET AZIMUTH-REFERENCE NORTH
   ⟶ ASTRO> DEVICE X W *(* DEVICE I W *on a* HP*)*
   ⟶ ASTRO> FRAME HORIZONTAL
   ⟶ ASTRO> SOURCE /DRAW *(to get an Az-El plot)*
   or
   ⟶ ASTRO> HORIZON /SOURCES *(to get an observability chart)*

   you can also use the PLANET *command and the* /PLANET *option to get plots of the same kind for planets*

   If you want a hard plot:

   ⟶ ASTRO> HARD /PLOT

3 Observing

3.1 The frontends

The OBS command for setting the receivers is the following:

⟶ OBS> RECEIVER *rx_name* /LINE *name* /FREQUENCY *value* /WIDE

Where the parameters are:

- *rx_name*: name of the receiver: A100, B100, C150, D150, A230, B230, C270 or D270
- *name*: the name of your line
- *value*: frequency value in GHz; not necessary if your line is defined in your line catalogue which can be set by the "SET CATALOG LINE YOUR_LINES.LIN" command
- /WIDE: if you want to tune the receivers in wide band (i.e. 1 GHz band); not available for the 100 GHz receivers

The possible receiver combinations can be found on our telescope system summary on our web page[2].

Example:

A possible 4 receivers configuration:

⟶ OBS> RECEIVER B100 /LINE 12CO(1-0) *(a line from your catalogue)*
⟶ OBS> RECEIVER A100 /FREQUENCY 103.567837 *(not in the catalogue)*
⟶ OBS> RECEIVER A230 /FREQUENCY 224.585894
⟶ OBS> RECEIVER B230 /LINE 12CO_RED /FREQUENCY 231.119740 *(to define a name for this line not in your line catalogue)*

3.2 The backends

Here are the OBS commands you need to set the backends: the 1MHz, the AUTOCORRELATOR and the 100KHz.

The 1MHz filterbank:

⟶ OBS> 1MHZ *part_number channels f_shift* /RECEIVER *name*

- *part_number*: an integer as a label for the backend part
- *channels*: the number of channels. Can be either 256, 512 or 1024. 1024 channels can be used in total
- *f_shift*: the frequency shift in MHz
- *name*: receiver name

Examples:

⟶ OBS> 1MHZ 1 256 /RECEIVER B100
⟶ OBS> 1MHZ 2 512 /RECEIVER B230
⟶ OBS> 1MHZ 3 256 50 /RECEIVER C270

with the last command, the centre of your window will be shifted by 50 MHz (actually 64 MHz since it rounds it to the closer 32 MHz multiple)

[2] **http://www.iram.es/rxcabin/news.html**

The autocorrelator:

⟶ OBS> AUTOCORREL *part_number res bw f_shift* /RECEIVER *name*

- *part_number*: label for the backend part
- *res*: resolution in kHz
- *bw*: bandwidth in MHz
- *f_shift*: the frequency shift in MHz
- *name*: receiver name

Examples:

For each part, the resolution and the bandwidth determine the percentage of the autocorrelator used (see example below). You cannot of course use more than 100 %. See the 30m manuals page 14, and the OBS manual page 14 to see the allowed bandwidths, the resolutions and the related percentages of the autocorrelator used.

⟶ OBS> AUTOCORREL 1 40 20 /RECEIVER A100 *(12.5% used)*
⟶ OBS> AUTOCORREL 2 80 40 /RECEIVER B100 *(12.5% used)*
⟶ OBS> AUTOCORREL 3 320 160 /RECEIVER A230 *(25% used)*
⟶ OBS> AUTOCORREL 4 1250 640 /RECEIVER B230 *(50% used)*

The 100 kHz filter-bank:

⟶ OBS> 100KHZ *mode f_shift* /RECEIVER *name*

- *mode*: can be:
  - SERIES: 2×128 channels of 100 kHz for 1 receiver
  - PARALLEL: 2 windows of 128×100kHz centred at the same frequency for 1 or 2 receivers
  - SPLIT: 2 windows of 128×100kHz for 2 receivers tuned at different frequencies
- *f_shift*: the frequency shift; 2 shifts can be entered with SPLIT
- *name*: receiver name

Examples:

⟶ OBS> 100KHZ SERIES /RECEIVER A100
⟶ OBS> 100KHZ PARALLEL /RECEIVER A100
⟶ OBS> 100KHZ PARALLEL /RECEIVER A100 B100
⟶ OBS> 100KHZ SPLIT /RECEIVER A100 B230

3.3 Parameters

OBS recovers "standard" values for all the parameters such as the efficiencies and the cold load temperatures (these standard values can be found on our web site[3]). In case it does not:

[3] **http://www.iram.es/rxcabin/news.html**

Forward efficiencies:

⟶ OBS> SET FORWARD *value* /RECEIVER *name*

- *value*: value of the forward efficiency
- *name*: rx name

Cold load temperatures:

⟶ OBS> SET CHOPPER * *value* /RECEIVER *name*

- *value*: value of the cold load temperature (ask the operator)
- *name*: rx name

Rejections of the image side band:

⟶ OBS> SET GAIN_IMAGE *value* /RECEIVER *name*

- *value*: value of the rejection
- *name*: rx name

The operator will give you the values of the rejections[4] after the tunning of the receivers (see below).

3.4 The observation modes

For a complete description of all the observing modes, please refer to the OBS manual. We will here restrict our examples to position, wobbler and frequency switching.

Position switching:

⟶ OBS> PSWITCH 600 150 BASIS /TIME 30 /SYM

"600 150" is the off position in arcseconds in the "BASIS" system (the one you chose in your source catalogue). You can also select the horizontal sytem (with HORIZONTAL). /TIME will give 30 seconds per subscan (recommended). We advise you to use the /SYM option (OFF-ON-ON-OFF series) which gives better baselines.

Wobbler switching:

⟶ OBS> WSWITCH 210 /TIME 30 /PHASE 2

Select a wobbler throw of 210 arcsec (wobbling only in azimuth, maximum of 240 arcsec) with subscans of 30 seconds and 2 seconds of integration for each position "on" source and "off" position.

[4]usually in dB, but you have to enter the actual value

Frequency switching:

⟶ OBS> FSWITCH 7.9 /TIME 30 /PHASE 2 /RECEIVER A100

The local oscillator frequency will be shifted by 7.9 GHz (corresponding to the subreflector ripple; this value or twice this value are recommended[5]). During subscans of 30 seconds, the integration will be done for 2 seconds on each phase (i.e. with the local oscillator shifted and not shifted).

4 Observations

4.1 Getting started

If you are new to the telescope, ask the astronomer on duty to assist you.

1. Log on IRAMEA on the observation terminal by clicking on the OBS icone. Enter your username and your password (as before).
2. Tell the operator which receiver configuration you want to use and if you will use the wobbler. Then start the OBS control program by typing "OBS".
3. select your catalogues:

   ⟶ OBS> CATALOG LINE YOUR_LINES.LIN
   ⟶ OBS> CATALOG SOURCE YOUR_SOURCES.CAT

4. Set the backends (with 1MHz, AUTO, 100kHz ...) and frontends (with RECEIVER ...) configuration.
5. Check if the efficiencies and the cold load temperatures are ok and correct them if necessary (with SET FORWARD and SET CHOPPER). The standard values can be found on our web site[6] or by near the observers desk.
6. Select a source (see below).
7. The operator will then tune the receivers (about 10 mins)
8. Set the correct values for the rejections of the image gain (with SET GAIN_IMAGE) if necessary; ask the operator.

4.2 Pointing and focusing

First you have to check the focus on a strong source, a planet or one of the strongest pointing source (a catalogue and Az-El plots of the pointing sources can be found on the observers desk).

1. Select your source:

   ⟶ OBS> SOURCE *planet_name*

   e.g: "SOURCE MARS"

   Or for a source from our pointing catalogue:

[5] see IRAM Working Report No. 228/95, a copy can be found on the observer desk
[6] **http://www.iram.es/rxcabin/news.html**

$\longrightarrow$ OBS> SOURCE *pointing_source* /CATALOG *

*you may want to fix the radial velocity setting of the receivers to prevent them getting out of lock and use the "/*VELOCITY *velocity_value" option*

e.g: SOURCE 0439+360 /CATALOG * /VELOCITY 50.6 LSR

where 50.6 kms^{-1} *is the velocity of your source. The velocity type (LSR, HELIOCENTRIC or RED) defaults to the type defined in your source catalogue*

2. Select the continuum backend:

   $\longrightarrow$ OBS> CONTINUUM BROAD SWITCH /RECEIVER A100 D150 A230 D270

   only the result of the first receiver (the "channel 1") in this list, will be used for the correction of the focus and pointing (see below). You can change it with " SET CHANNEL *number" (you should use a 3mm receiver since we observe quasars, stronger at 3mm, for pointing and focus)*

3. Now you can check the pointing:

   $\longrightarrow$ OBS> POINTING

   commands the telescope to scan twice in Az and El; Gaussian fits of the data are displayed in the RED windows

4. If the fits look good , take the correction with:

   $\longrightarrow$ OBS> CORRECTIONS F F

   *or "*CORRECTIONS *value1 value2" if you have to enter your own values, in the case the fits are poor (ask the* AOD*). Value1 and value2 are the absolute true angles*[7] *offsets, i.e.* COL* *and* NULE *(showed in the* OBS *window), and not the values of the observed error in "azimuth*[8] *" and elevation.*

5. Then check the focus:

   $\longrightarrow$ OBS> FOCUS

   this observes the source with various focus settings and fits the observed points

6. if the fits are ok, take the correction:

   $\longrightarrow$ OBS> CORRECTIONS * * F

   you can also enter your own values. The "" means that you do not take the correction, for the pointing in that case (since you already corrected for it)*
   repeat the focus determination at least after sunset and after sunrise

[7] Az$\times$ cos(El) and El

[8] which is actually ΔAz$\times$ cos(El) but is called "ΔAz"

7. Now you can select a pointing source near your source and point on it:

   ⟶ OBS> SOURCE *point_source* /CATALOG *
   ⟶ OBS> POINT

   repeat the pointing every 1 or 2 hours or if you change to a different direction in the sky

8. if it is ok take the correction and go to your source:

   ⟶ OBS> SOURCE *calibrator* /CAT MRT$DATASAVE:LINES *(this is the name of the catalogue)*

9. Select your backends (just by typing 1MHZ, AUTO or 100KHZ if you have already defined them).

10. Do a calibration:

    ⟶ OBS> CALIBRATE COLD

    This has to be done each time you change from one source to another, when you change the backends or after 5-15 minutes on the same source, depending on the atmosphere. It will give you the receiver temperatures, the system temperatures, the opacities and the amount of precipitable water (seen in the RED *program window). Repeat the calibration in case the obtained receivers temperatures are in doubt (standard values can been found near the observers desk)* or ask the staff

11. Select your observation mode (with PSWITCH, WSWITCH ...).

12. Set the number of subscans:

    ⟶ OBS> SET SUBSCANS *number*

13. Start the integration:

    ⟶ OBS> START

    A list of astronomical line calibrator can be found on the observer desk. These sources can be accessed with “SET SOURCE CALIBRATOR_NAME /CAT MRT$DATASAVE:LINES”. It is always a good idea to check the calibration measuring one of these lines if possible.

    You can write a little procedure for the integration, for instance:

    ⟶ EDIT /EDT WANNA_GO_FOR_DINNER.PRO

```
DEFINE INT LOOP_NUMB
LET LOOP_NUMB = '&1'

FOR I 1 TO LOOP_NUMB
        CAL COLD
        FOR J 1 TO 4
                START
        NEXT
NEXT
```

⟶ “control z” and “EXIT” to exit from EDIT

just run it by typing:

⟶ OBS> @WANNA_GO_FOR_DINNER

if for instance you have subscans of 30s and 10 subscans per scan, this procedure will do a calibration every 20 min

14. You may want to save every parameters and settings with “SAVE LAST” (LAST or whatever you want ...) which will create a “LAST.PRO” procedure containing every definition of your current setting. To recover everything from this configuration you just have to type “@LAST” next time you enter in OBS.

5 Quick look

During the observations you will certainly want to have a quick look to your data. You can find below a few CLASS commands you will need:

1. First open a window on IRAMEF or one of the HP (usual login name and passord)
2. You have to export the display:

   ⟶ export DISPLAY=mrt-lx7:0 *(this command is the same on the HP and the VAX)*

3. Enter in the spectral line data reduction package CLASS by just typing “CLASS”
4. you need to define a device:

   ⟶ CLASS> DEVICE X W on VAX or DEVICE I W on a HP

5. To get the data:

   ⟶ CLASS> FILE IN YOUR_DATA_FILE.30M

6. select the source you want:

   ⟶ CLASS> SET SOURCE *your_source*

7. now the backend:

   ⟶ CLASS> SET TELESCOPE IRAM-30M-Bxy

   x is the label of the backend: 4 for autocorrelator, 3 for 1 MHz and 2 for 100kHz; y is the part number you have selected before with the backends commands. Type HELP SET *to see what can be set*

8. once you have selecting everything (source, line, backend, offests, ... etc):

   ⟶ CLASS> FIND

9. If you want to have a look at each selected scan, write and run this little procedure:

   ⟶ EDIT /EDT HAVEALOOK.CLASS

```
GET F
PLOT
PAUSE
FOR I 2 TO FOUND
        GET N
        PLOT
        PAUSE
NEXT
```

   and execute it with:

   ⟶ CLASS> @HAVEALOOK

   after each plot if you want to see the next one, type "c" and "return". Before using this little procedure, "FIND" *is necessary in order to set the* FOUND *variable*

10. You can also sum the selected scans up with:

    ⟶ CLASS> SUM

11. and then:

    ⟶ CLASS> PLOT

    to see the results.

12. If you want to see new data when your are in CLASS it is not necessary to load the data file again:

    ⟶ CLASS> NEW_DATA

    is sufficient

13. at any moment you can make hard copies of your spectra:

    ⟶ CLASS> HARD /PLOT

    or

    ⟶ CLASS> HARD *file_name.ps* /DEVICE PS COLOR

    to make a postscript file.