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1 Introduction

This manual briefly describes how to carry out spectral line observations with the ARcetri COrrelation Spectrometer (ARCOS) installed at the Medicina and Noto radio telescopes. More detailed information can be found at
`http://www.arcetri.astro.it/science/Radio/red/red.html`
First, the hardware and software are described, followed by all the steps from the preparation to the execution of an observing session.
Data archiving is left to the Arcetri staff, as a unique database is maintained at the Arcetri Astrophysical Observatory
(`http://www.arcetri.astro.it/science/Radio/red/nuovastrut.ps`)

2 Description of the instrumentation

Spectroscopic observations at Medicina and Noto make use of the following hardware units and software components:

The Field System The VLBI data acquisition system. It is run under Linux OS and is used to control the antenna movements and the receiver. The Field System can communicate with the outside world via a serial link handled by the *fs2com* server program. The SNAP command language is used to type commands directly in the *operator input* window . During spectroscopic observations these commands are most frequently used to start up or stow the telescope, to move to a calibrator source, or to open and close the antenna log file.

The ARCOS correlator The correlator provides up to 2048 lags and can be split into two correlation units (sections):
`http://www.arcetri.astro.it/science/Radio/instr/arcos.html`

Two video band amplifiers They are used to condition the signal at the correlator sampler inputs.

A PC (DOS compatibile) It is equipped with a HPIB interface and a serial port. The data acquisition program ADLB4ARC and the quick-look analysis program SPETTRO run on this unit.

ADLB4ARC The data acquisition program. It provides a GUI trough which all relevant operations are performed. Batch files are supported so that observing operations may be highly automated.

SPETTRO The quick-look analysis program. It reads the autocorrelation function from the input file, applies the FFT to compute the signal power spectrum and saves the result on disk.

METTIVIA The archiving utility, to be run *no more than once a day.*

All these units are located in the telescope control room. The actual locations are different at the two sites and may change from time to time, so new users should refer to the local staff for exact information.
The Noto telescope is equipped with an *active surface control unit* but hopefully a spectroscopic observer has no need to interact with it.

3 Preparing an observing file

For any observation that is not a short test, it is convenient to have the sources to be observed in a schedule file, that can be fed into the observing program for automatic execution.

An example of such a file is shown here:

```
project   MYPROJECT
restfreq  22235.07985 mhz
obsmode       bmsw
refpos       radec
ralfa      -1.0000 d
rdelta      0.0000 d
input goto
IRC+10011:
source IRC+10011
sra50 1 3 48.1
sdec50 +12 19 51
intgtime  300 s
acbandwidth  10.0 mhz
vlsr  -3.50 km/s
obscycles  2
beep 5 s
run
*** IRC+10011  observed ***
OCET:
source OCET
sra50 2 16 49.1
sdec50 -3 12 23
intgtime  300 s
acbandwidth  10.0 mhz
vlsr 36.5 km/s
obscycles  2
beep 5 s
run
*** OCET observed ***
input goto
stop:
stop
```

This file, called *myproject.sch*, observes two objects. Each will be observed for 5 min. ON-source, and for 5 min. at an OFF-position located 1° West. This ON-OFF cycle is repeated twice.

This file can be prepared by executing a small procedure in a unix session:

1. Create *myproject.dira* with RA (in `hhmmssddd` format), Dec (in ±`ddmmssddd` format), Source name (between quotes, max 10 char.), Velocity (km/s), Int. Time (sec), Bandwidth (MHz), Number of integrations.

2. Run the program `arcobs` using *myproject.dira* as input and create myproject.sch. The `arcobs` program source can be found in
   `http://www.arcetri.astro.it/science/Radio/red/arcobs.tar.gz`.

   `arcobs` can be run interactively or in batch mode:

   Interactive mode Type `arcobs` and input all the parameters as they are requested by the program.

   Batch mode Type `arcobs` *myproject.dira arcobs.prm*.

   arcobs.prm indicates any file containing a list of session parameters. Typing the command `arcobs -help` you will get a list of the parameters that can go into this file.

   The output is written to *standard output* (i.e. the screen) so that you can check it.

   Once you are satisfied you can redirect the standard output to the file *myproject.sch*: `arcobs` *myproject.dira arcobs.prm* > *myproject.sch*.

3. Give the command `unix2dos myproject.sch > myproject.dos` to convert the file in DOS format for ADLB4ARC

4. Finally `mv myproject.dos myproject.sch`

For the example shown above, myproject.dira would look like this:

```
010348100 +121951000    IRC+10011         -3.5  300 10.0 2
021649100 -031223000    OCET             +36.5  300 10.0 2
```

One may run `schedule myproject.dira` to create a visibility plot

4 Setting up an observing session

We now review the operations necessary to start an observing session. A more detailed checklist is avalable at the URL `http://www.arcetri.astro.it/science/Radio/red/checklist.html`. Three operations are required:

- ARCOS *bootstrap*.
- Activating the link between the correlator control PC and the Field System
- Set-up of the working environment on the data acquisition PC.

4.1 ARCOS Bootstrap

We shall assume that ARCOS has been properly connected to the Base Band Converters. Switch on ARCOS together with its monitor. The ARCOS main switch is on the rear of the rack. At power-on the autotest starts, the installed hardware is detected and the server program *adlb_serv* is started. When all this is finished, the ARCOS monitor will show:

```
adlb_server program started
Version .......
(ARCOS IP address)
```

Check that the led `SysFail` on the ARCOS GPIB-1014 (IEEE488) card is lit up green. If the led is red, this means the card has not been initialized correctly and there is no link with the data acquisition PC. Try to switch off and on again. If the error persists, call Francesco Palagi (055-2752 216) or Gianni Comoretto (055-2752 215) at Arcetri.
Switch on the video amplifiers (the box directly above ARCOS).

4.2 Field System

If the Field System is not already active, ask the station's technicians to activate it.
First check that there is a window with the *fs2com* program running — the Field System is ready to receive commands from the serial line.
If it's not, open an `xterm` window on the Field System terminal by moving the mouse on the desktop and then click the left button (a menu pops up), then select `new window`. From this new window launch the communication program with the command:

```
prompt> fs2com
```

In this window one will see messages that indicate the communications link is active.
Secondly, change the log file. From the window `Operator Input` give the command:

```
prompt> log=adlb4arc
```

Then one needs to define the parameters of the receiver in use. For the prime focus 22 GHz receiver, the command is:

```
prompt> setupkkp
```

For other receivers ask the staff technicians.
At the end of the session, do not forget to take with you the log file (written into directory `/usr2/log`).

4.2.1 Setting up the antenna

From the Field System `Operator Input` window give the command:

```
prompt> antenna=setup
```

In this way the antenna is set up to be controlled by the computer, through a series of procedures that result in a large number of on-screen messages, that are of no concern to the observer. You have to wait for about one minute to allow full extraction of the stow-pins before you can move to a new position.
Put the antenna in the *tracking* status with the command:

```
prompt> antenna=track
```

4.3 Setting up the working environment on the PC

The main switch is located on the front of the PC tower. The screen is switched on together with the PC. At the end of the PC's *bootstrap* one finds the prompt:

LILO

Press the <`shift`> key followed by `win95` to start up `Windows95`. At the end of this operation the screen shows a number of icons, among which there are those of the programs `ADLB4ARC`, `SPETTRO`, and `METTIVIA`.
At start-up `ADLB4ARC` reads the file named `startup.fir` which contains all the configuration commands, i.e. commands that usually are not issued during normal operation.
There are several configuration files, one for each receiver/line session. To set-up the ADLB4ARC environment one needs to copy the relevant configuration file into the `startup.fir` file:

1. Open a DOS-window: move the cursor to the lower edge of the screen, and a horizontal bar will appear. Click on `start`, and from the resulting menu choose `DOS Windowed` and a window emulating DOS will open.

2. Move the cursor into this window and go to disk D; then define the working directory `ADLB4` by typing the command:

```
prompt> D:
prompt> cd \adlb4
```

3. Copy the configuration file that refers to the receiver in use and the type of observation to be carried out into the file `STARTUP.FIR`.

The configuration files are in the directory `\adlb4\config`.
ATTENTION ! The files in directory `\adlb4\config` must not be modified or deleted without authorization by Palagi or Comoretto.
Copy your own observing file (*myproject.sch*) to the directory `D:\\adlb4` (Medicina) or `C:\\adlb` (Noto).
Start the program `ADLB4ARC` by double *clicking* on the corresponding icon.
The main operations required to observe are summarized in the next section.

5 Observations

At this point you are ready to observe. For simple observations (usually a test scan) type in the necessary parameters in the template on the screen and click the button `START`. Normally, it should be enough to specify:

- Source name and program identification
- Source coordinates (*B1950!*).
- Integration time in seconds.
- Type of scan (usually beam switch).
- Number of repeat observations (usually one does not exceed 5 minuts for a single integration)
- Central LSR velocity
- Bandwidth

For regular program observations it is common to put these parameters in a file, that can be generated by the program `arcobs` (see Sect. 3).
Before you start a session a test observation is recommended. Files are available for H_2O (w3oh.sch) and CH_3OH (w3ohmeth.sch) sessions. For different lines they can be used as a template to create a new one. W3OH is used because it is a circumpolar strong maser source.

5.1 Observing files

Suppose one already has prepared an observing file, and that it has been copied into directory `ADLB4` on the PC, as described above.
To start an observing file, enter into command mode (button `[F3]`), and give the command `file myproject.sch`. Normally, the program will ask for the first source to be observed. At the prompt

```
goto>
```

reply with the name of the source, exactly as it appears in the observing file.
To interrupt an observation, press either `HALT` (stops after the presently active on-off cycle), or `BREAK` (stops immediately, *without saving the current spectrum*).

5.2 Calibrations

In order to get useful spectra, they have to be calibrated. For this, the antenna gain curve has to be measured. This is done via a series of procedures and programs that are run from the Field System terminal.

Proceed as follows:

- Press `HALT` on the ADLB4ARC PC.
- Wait for the present observing cycle to finish.
- Press `EXIT` and leave the program.
- From the Field System `Operator Input` window give the command:

```
prompt> calkk_dr21
```

This will perform a series of cross scans in azimuth and elevation on the source DR21 (which is effectively the only calibrator in use for spectral line observations at Medicina). This will take approximately 10 minutes.

One should do a calibration measurement roughly once an hour during the time that DR21 is visible, making especially sure to also observe DR21 at low elevations ($\sim 15^\circ$).
During the calibration measurements, the control PC is available for a quick reduction of the spectra, with the program `SPETTRO`.

5.3 Quick-look data reduction

5.3.1 SPETTRO

The program `SPETTRO` works from its own DOS-window, and is activated by *double-clicking* on the corresponding icon on the desktop. The `SPETTRO` user manual can be found at `http://www.arcetri.astro.it/science/Radio/red/spettro.ps`.

Raw spectra are written into the file `medi0000.acf`. When launching `SPETTRO`, this file is automatically opened, and the default output file is called `medi0000.spt`. To list all the spectra in the *.acf file, type "`look`".

Select a pair of ON-OFF scans (say scan numbers 1000 and 1001):
`ON=1000`
`OF=1001`

The program may complain about the counts in channel 0 not being correct, and ask whether it should try to correct. The default answer is 'NO', and therefore simply do a carriage return.

The edges of the band are usually of very poor quality, and are already thrown away at this stage:

`drop 2 40`

will remove the worst bits of the spectra.

By default the spectra will be show in units of intensity (at this point, pre-calibration, this will still be in system units) as a function of channel number. Change to velocity scale by typing

`x km`

Then to get the spectrum ([ON-OFF]/OFF) do:

`plotr`

and to write it into the output file, type:

`out`

The contents of the output file can be seen by typing "`lis`".

Many spectra can be reduced at the same time, by using the command "`multi`". The program will then ask for the first and the last ON-source spectrum, and the only action required after this, is to it 'carriage return' until the last spectrum has been written to the output file by this procedure. Typing "`plot`" after this, the last spectrum in the series is shown on the screen.

5.3.2 AVER

When more than 1 pair of ON-OFF scans have been taken, one may create a sum spectrum by summing the individual, reduced spectra, using the program `AVER`. Give as input file `medi0000.spt` and as output file `medi0000.avg`. As before, commands "`look`" and "`lis`" will show the contents of the input and output files, respectively.

The command:

`a N1 N10`

will average scans N1, N2, N3, ..., N10

Plot the result by typing "`plot`". To get velocity (rather than channels) along the x-axis, type "`x km`". To write the result to the output file, type "`out`".
Before averaging scans from a new source, type "`clear`" first to clean the stack.

6 Closing down a session

At the end of a session one has to:

- Change the name of the file `adlb4arc.log` to be able to tranfer it to Arcetri, via `ftp`.
- Archive the files `medi0000.*`

The first operation is executed on the Field System:

- from the window `user input` close the file `adlb4arc.log` with the command:

```
prompt> log=station
```

- then:

```
cd /usr2/log
mv adlb4arc.log adlb4arc.log.YYMMDD
 cd ~\oper
```

The second operation is carried out from the control PC, clicking on the icon '`METTIVIA`'. This will automatically transfer the files `medi0000.acf` and `medi0000.spt` to the directory /adlb/acfs. This procedure attaches the (UT-) date to the file names, and therefore `METTIVIA` should be executed *only once per 24 hour (UT-) period*, otherwise the results of the previous `METTIVIA` will be lost!

7 Problems

Please note down all problems encountered in the notebook kept in the control room for this purpose. Enough details should be provided to allow the observatory staff to solve and hopefully prevent future occurrences of the same problem.
The more common problems one can encounter are:

7.1 The PC does not communicate with the antenna

Check that the cable RS232 is connected between the com2 of the PC and port 2 of the Field System PC.
Check that the program fscom has been launched and is active. From the window in which it has been started, the program responds with messages every time it receives a command from the data acquisition PC. Try to kill (control-C) and restart the program.

7.2 Error of initialisation or of comunication with the correlator

Check that the program `adlb_serv` on the terminal of the VME machine. One can try to reset and restart this machine. The reset-switch is on the front of the CPU unit. Lift it for 1 second and repeat the boot-procedure on the terminal.

7.3 The obs. schedule starts, but does not accept the source name

Stop the schedule (with `BREAK`), manually insert the source name, and restart the schedule.