INTERNAL REPORT

Observing with the DFB at SRT: Practical notes for the user

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Abstract:

The "Dummsy" program, combined with the "tkds" GUI, provides control of the Digital Filter Bank (DFB) backend. This document presents the different steps for manually carrying out an observation using the DFB in both folding and search modes. When the SEADAS [1-3] software is ready, data acquisition will be automated. For now, the setting of parameters is done manually and has to be performed in a specific sequence in order to correctly complete an observation. The current status of the DFB allows the observer to only use a single-band receiver at a time. It will later be possible to observe in parallel with the L and P-band receivers.

(#) continued from cover page:

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CONTENTS

INTRODUCTION

The Pulsar Digital Filter Bank (PDFB) system [4-5] was developed by the ATNF (Australia Telescope National Facility). It was installed at the Sardinia Radio Telescope in 2012 [6]. Two of the four operating modes have been implemented: folding mode and search mode. The baseband and spectrometer modes will be implemented later.

The PDFB is able to process up to 1 GHz of bandwidth. Because of the effects of interstellar dispersion on pulsar observations, the observed bandwidth is divided into narrow channels. The observer can choose the bandwidth and the number of frequency channels, selecting one of the predetermined configurations.

This document presents the steps to follow in order to manually perform an observation using either folding mode or search mode. The commands related to the control of the antenna via the Nuraghe software are consistent with version 0.4.

Before you begin, ask for the password needed to access the VNC session and psrdfb on the nuraghe-obs1 machine.

1) SWITCHING ON THE DFB

The DFB backend [4-6] is located in box AP, on the left side of the Roach computer cluster, in the second rack from the right (see Figure 1). Switch on the red button situated on the back of the DFB. Close the back of the rack.

Figure 1: Location of the Pulsar Digital Filter Bank (DFB) in box AP.

Check that the cables of the receiver you will use to perform your observations are correctly connected to the left board of the DFB, on the front of the DFB, as shown on Figure 2. The cables are identified by the label with the name of the receiver. For C-band or P-band, DFB1 and DFB2 cables have to be connected to the DFB, whereas for L-band, DFB3 and DFB4 cables are connected. Only the authorized personnel is allowed to perform the change of cables to observe with another receiver. Note that for P-band observations, it is necessary to connect a different attenuator to the DFB in order to correctly attenuate the signal (to be checked by the authorized personnel).

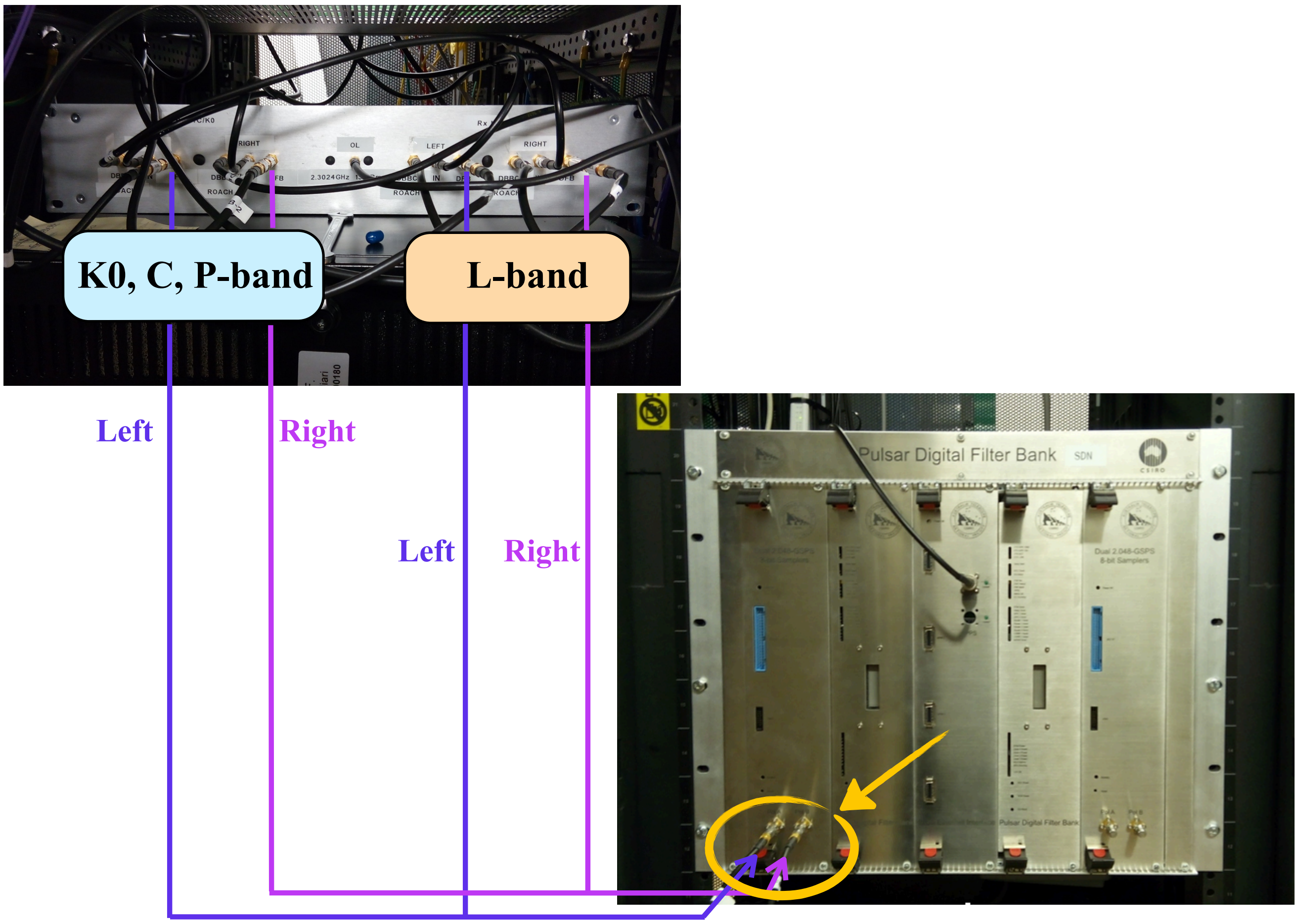

Figure 2: Illustration of the left and right polarization cables that connect the receivers to the DFB. The observer has to check that the cables of the selected receiver (see the labels on the cables) are connected to the lower left part of the DFB indicated by the yellow arrow.

Several warning lights are visible on the front of the DFB. One of the most important ones is the temperature alert, which is visible on the upper light on the left board (l-bcc11). If this light is red, the data acquisition has to be stopped for at least 10 minutes (see **NOTES** p.21 of this document).

For now, it seems impossible to observe with the Roach in parallel with the DFB, because of the high temperature generated by the cluster.

2) STARTING NURAGHE AND SETTING UP THE RECEIVER

Depending on the band of the receiver, set the parameters related to the observation on the Nuraghe operator input, as shown in the following. Remember that the Total Power system works as a focus selector, sending the signal from the selected receiver to the other backends. That is why it must be set up even if you want to use the DFB backend. The first 100 MHz of the Total Power system are filtered, and only four possible options are available for the choice of the bandwidth: 300 MHz, 730 MHz, 1250 MHz and 2000 MHz.

For C-band (5.7 - 7.7 GHz), set the local oscillator value and the adequate bandwidth on the Nuraghe operator input (see example below). In order to avoid aliasing, the filter of the Total Power system has to be inferior to the chosen bandwidth of the DFB. For instance, to observe 1 GHz of bandwidth with the DFB, the `setSection` has to be set at 730 MHz, whereas for 512 MHz (DFB's bandwidth), the corresponding `setSection` will be 300 MHz (Total Power). However, if aliasing is not a problem for your observation (e.g. the observation of a long period pulsar), you can select `setSection` of 1250 MHz to observe 1 GHz with the DFB, and `setSection` of 730 MHz to observe 512 MHz with the DFB. You could check the effective DFB bandpass at the Section 7.

C-band:

```
> setupCCB
> asSetup=S
> setServoASConfiguration=ON
> setServoElevationTracking=ON
> setLO=…                          # insert the value of the LO (in MHz)
> setSection=0,*,1250,*,…          # choose the adequate filter for the Total Power
> setSection=1,*,1250,*,…
```

For L-band (1.3 - 1.8 GHz) observations, check first the value of the local oscillator in box AP (see Figure 3). It should indicate 2316 MHz, frequency chosen for the LEAP sessions, or 2324 MHz, which is the value selected for the VLBI sessions and the monitoring RFI with the DBBC. The calculation of the central frequency with the DFB will take into account this shift of 8 MHz. The bandwidth of the Total Power has to be set to 2000 MHz (value by default).

L-band:

```
> setupLLP
> device=0
> receiversMode=XXL4
> asSetup=P
> setSection=0,*,2000,*,…          # if not already set to 2000 MHz
> setSection=1,*,2000,*,…
```

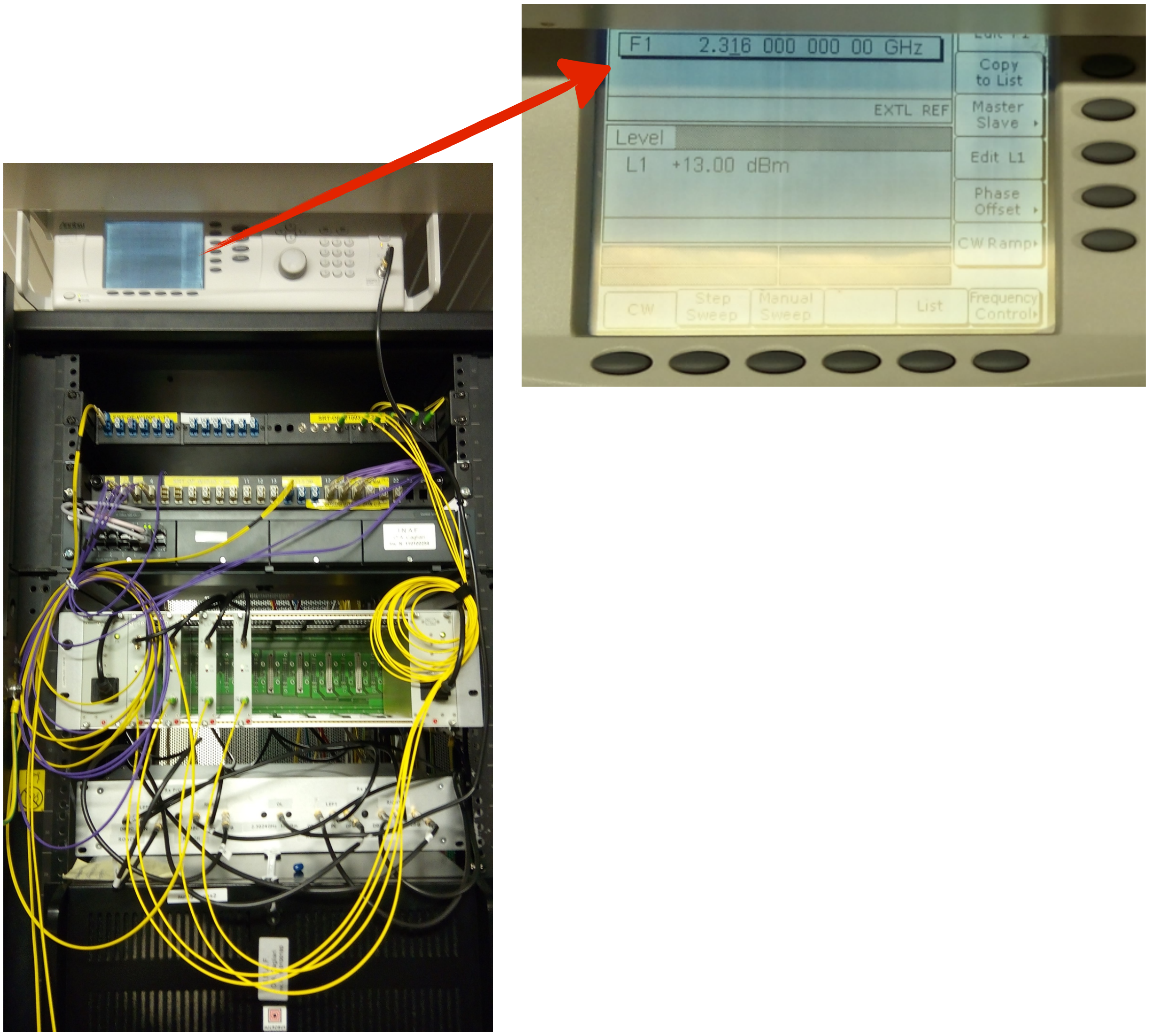

Figure 3: Local oscillator for L-band in box AP. The frequency has to be checked in order to calculate the central frequency with the DFB. On the right picture, the LO is set at 2316 MHz.

For P-band (305 - 410 MHz) observations, the encoders of the PFP have to be switched off since they produce interferences that make the observations impossible. At present, this operation is performed in apex. Only authorized personnel is able to do it. Therefore P-band observations have to be planned in advance with the SRT personnel. The local oscillator is not necessary since the band is already in the DFB band. Select the configuration of the band filter and polarisation mode, and set the bandwidth of the Total Power at 730 MHz to avoid aliasing.

P-band:

```
> setupPPP
> device=0
> receiversMode=L3XX
> asSetup=PF
> setSection=0,*,730,*,…
> setSection=1,*,730,*,…
```

Then, set the “inital” attenuations, starting with a high value (about 15 for L, P, and C-bands). A safe value should be at about 5, but it is strongly recommended not to take any risk and so to begin with a higher value such as 15. The value depends on the attenuator(s) located at the entries of the DFB. You can check the value before beginning.

```
> setAttenuation=0,15
> setAttenuation=1,15
```

The values will be later corrected (section 4), looking at the rms values associated with the DFB.

3) COMMUNICATING WITH THE DFB

Go on the MISC workspace of nuraghe-obs1 (third tab on the virtual desktop). In order to interact with the DFB, open a VNC session and enter in psrdfb.

```
> vncviewer -shared psrdfb:1
```

which is equivalent to `> vncviewer -shared 192.168.200.155:1`

After entering the password, the psrdfb graphic desktop should appear.

Note: If you are not asked for the password and the connection is refused, it means that you have to set up the vnc server. To do this, open a terminal and log in psrdfb as corr.
Give the following commands:

```
> ssh -X corr@192.168.200.155      # password
> vncserver -kill :1               # to kill the vnc server :1 if it exists
> vncserver -geometry 1920x1000    # the option -geometry simply sets the dimensions
                                     of the desktop.
```

Then log off from psrdfb and connect to it with the previously-mentioned vncviewer command.

Open 4 windows using the mouse’s left button, and select "`Xterm`". The first one allows the observer to check the clock, the second one and the third one are used to open the graphical interfaces (pdfb3 and tkds) for the data acquisition system of the DFB, and the last one will be dedicated to check the data.

a) Terminal 1: Checking the clock with atdc

The verification of the clock’s synchronisation is performed via the command atdc (Australia Telescope Distributed Clock).

```
> atdc
```

Press `enter` to all of the default values (terminal line, clock display) until you see the actual UTC, LMST and Local time in big fonts. Check whether the UTC is correct, the tick phase (ns) is in the order of some hundreds (the value can be positive or negative), and the status is ok. There is something wrong if the value of the tick phase is huge. See [6] for the procedure of synchronisation of the clock; this procedure has to be performed only by the authorized personnel.

Type "`q`" to quit.

b) Terminal 2: Checking the DFB parameters with pdfb3

Give the command `pdfb3`:

```
> pdfb3
```

A window appears (see Figure 4) and allows us to control in real time the values of the parameters of the DFB, such as the temperature, the rms, and the configuration file.

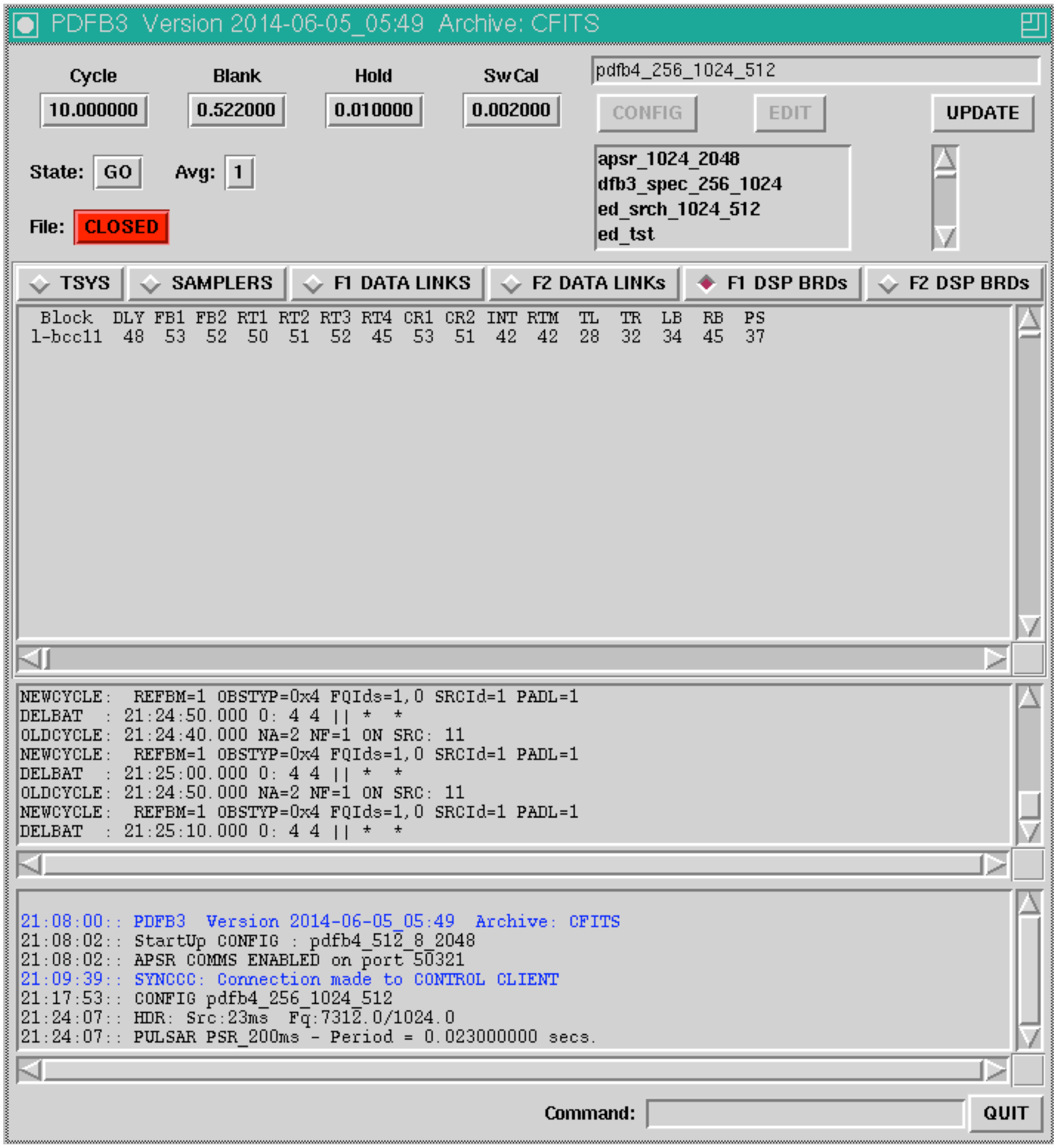

Figure 4: Screenshot of pdfb3 reporting the status of the DFB and the observations. The selected tab "`F1 DSP BRDs`" indicates the DFB's temperatures.

When the pdfb3 window is opened, by default you will not see any value. During an observation, the DFB's temperature must remain below 70°. The values will be indicated in the tab "`F1 DSP BRDs`" and will have to be checked regularly. The rms will have to be around 10. This value (visible on the tab "`SAMPLERS`") will later be reached by modifying the attenuation on the Nuraghe operator input (section 4).

Important: the temperature and the rms can only be checked in folding mode.

Note: If pdfb3 does not properly start, it means that a previous process is running and needs to be killed. To do this, close any DFB3 graphical interface by clicking on its `QUIT` button, and give the following command:

```
> corkill
> bcckill
```

Then re-start `pdfb3`. The same procedure has to be used in case there are problems with tkds.

---

c) Terminal 3: Input observing parameters with tkds

Start `tkds` from a third terminal to run the DFB's control program called "Dummsy":

```
> tkds
```

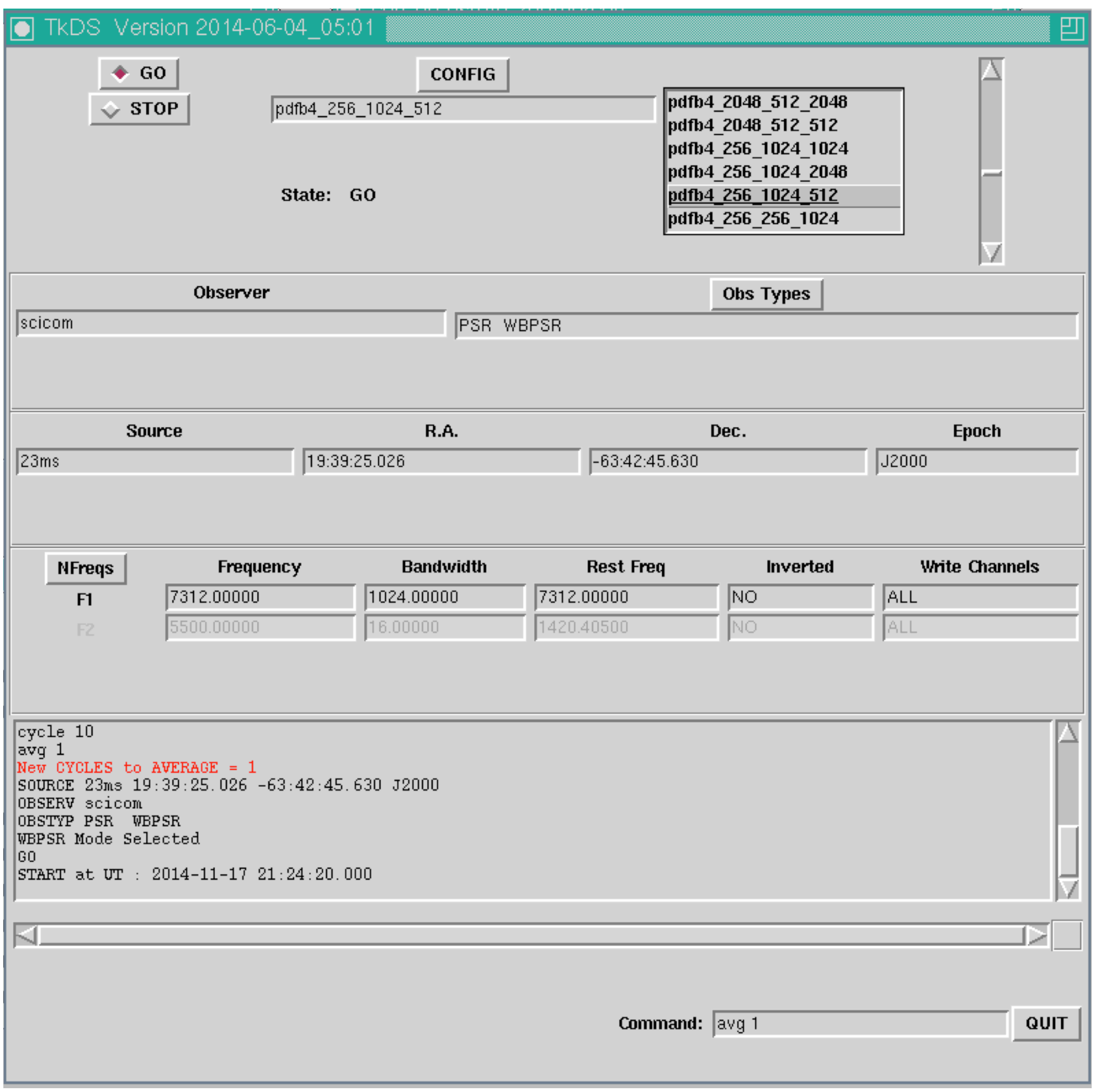

Figure 5: Dummsy program's GUI used by the observer to interact with the DFB.

See [7] to get the complete list of commands accepted by Dummsy.

Some useful recommendations:

- Whenever you have to enter anything in any tkds field, make sure that the mouse pointer is inside the field you want to write in.

- You have to press "return" after typing every single entry.

- In the bottom section of both pdfb3 and tkds, messages appear whenever an action is done. Check those panels to be sure that the action is correctly executed.

4) INITIAL SETUP

Before observing a source with the DFB, it is necessary to set the correct attenuations, which will reflect on the values of the rms. At present, the search mode does not allow us to check the values of the temperature of the DFB, nor the rms. That is why it is necessary for all observing modes to first insert a configuration of the folding mode and perform a fake observation. Once the rms is in the appropriate range, you could observe with the DFB using either the folding mode (section 5) or the search mode (section 6).

In the graphical interface associated with tkds, insert/edit the following parameters:

a) Choose a configuration file

Select the DFB configuration file by scrolling up the upper right panel of tkds or pdfb3. The files are in alphabetical order. All of the existing configuration files for SRT are listed in Appendix A. For the folding mode, the files begin with `pdfb4` followed by the time bins (used in the folding mode to divide the pulsar period into a number of time bins), bandwidth, and frequency channels, such as: `pdfb4_512_512_512`. The available bandwidths are 8, 16, 32, 64, …, up to 1024 MHz. Note that the configuration files `pdfb3_bin_bw_ch`, which are created for dual-receiver systems, do not work right now. They will be used to observe simultaneously with the L and P-band receivers.

If you want to observe in search mode, choose a configuration file of the folding mode that has the same bandwidth and frequency channels.

After selecting your configuration, press the `CONFIG` button. You should read in the pdfb3 window the name of the configuration file. A terminal-like window should also appear: it shows the progress of the configuration procedure. When the DFB configuration ends, this window should automatically close. If not, press “enter” until it closes. If it does not close after 3 “enter”, press `enter` and then type `quit`.

b) Fill tkds fields

Insert the required information about the observer and the observation types :

Observer : `scicom` (press "return" each time after inserting a parameter)
Obs types : `PSR WBPSR` (click on "obs types" to select it; WBPSR is for wideband pulsar mode)

In the following fields, which are related to the name and the coordinates of the source (RA and Dec), let the source name and values by default. Indeed, before observing the real source, it is necessary to check the values of the temperature and attenuations (rms close to 10) using the folding mode. To do that, you can perform a fake observation on the source "23ms" (source by default). It is a dummy pulsar to check that the DFB levels are correct.

Then enter the values of the chosen central frequency, bandwidth, rest frequency (which is equal to the central frequency for pulsar observations), and whether the frequency is inverted or not. These values have to be compatible with those selected in the configuration file. The central frequency corresponds to the sky frequency in MHz of the center of the baseband.

For C-band, the central frequency corresponds to the value of the local oscillator (written in NuragheConsole) plus half of the bandwidth of the DFB, with the frequency not inverted.

For L-band and P-band, the calculation of the central frequency and the fact that the frequency is inverted or not is less simple. See Appendix B to determine these parameters.

You can also have a look at Appendix C to see the most common configuration files and parameters to set (central frequency, bandwidth, frequency inverted or not), and in which case it is more convenient to select these parameters.

Example in L-band:

Frequency : `1556.0` # in MHz (in this example, LO=2324 MHz); see Appendix B
Bandwidth : `512.0`
Rest Frequency : `1556.0`
Inverted : `NO` # see Appendix B
Write channel : `ALL`

c) Input tkds commands

Enter the following commands in the Command field :

```
> site SRT       # SRT as site for tempo2
> fold           # folding mode
> cycle 10       # cycle time in sec (at least twice the pulsar period)
> avg 1          # number of cycles for which the data are averaged before being saved
```

Note that only the three first letters of the command names are enough (e.g. `cyc 10`).

Click on `GO` to begin the fake observation.

In the pdfb3 window, click on `SAMPLERS`. The rms values should be around 10.0, as illustrated in Figure 6. If they are lower than 10.0, it means that the incoming signal is too attenuated. Conversely, if they are higher than 10.0, it is too strong. If rms values are near 256.0, the signal is dangerously close to saturation and a higher attenuation is mandatory.

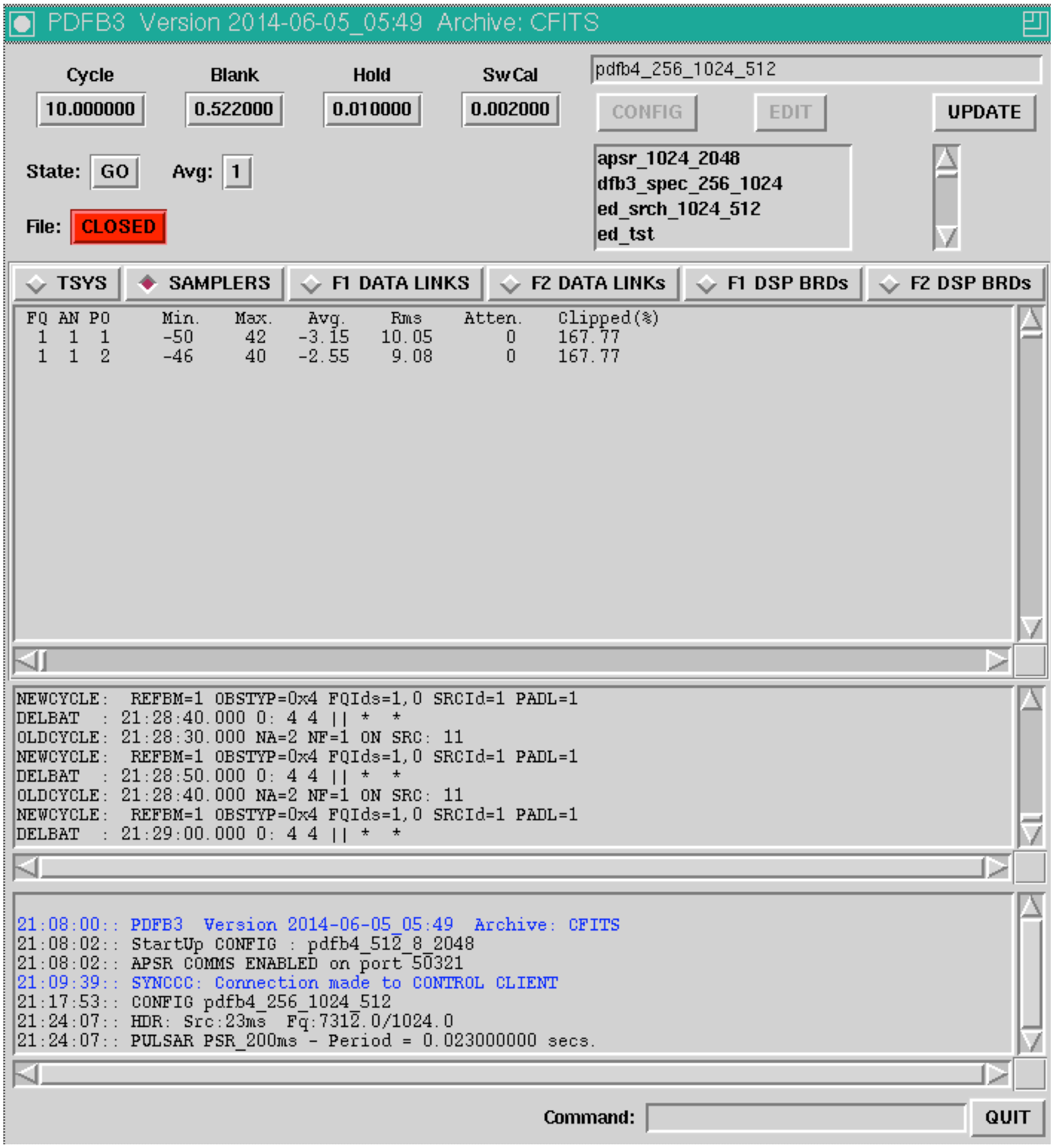

Figure 6: Screenshot of pdfb3 reporting the rms of the DFB in the `SAMPLERS` tab.

Adjust the signal intensity for both polarizations on the Nuraghe Operator Input:

```
> setAttenuation=0,…          # ajust attenuation
> setAttenuation=1,…
```

Once the signal levels are adjusted, check the DFB's temperature on pdfb3, in the tab "`F1 DSP BRDs`".
The dummy data acquisition can then be stopped by clicking on `STOP` on the tkds window.

The DFB is now ready to observe in folding mode (section 5) or in search mode (section 6). If you change the central frequency or the bandwidth, check the value of the rms.

5) OBSERVING IN FOLDING MODE

On the tkds window, choose the configuration file (then press the `CONFIG` button), frequency, bandwidth, and whether the frequency is inverted or not. Check the observer name (`scicom`) and observer type (`PSR WBPSR`). Remember to click on "enter" to confirm each parameter.

Put the antenna in tracking mode on the new source (on Nuraghe) following this example:

```
> sidereal=J1022+1001,10:22:58.131h,10:01:57.401,2000,neutral
```

Enter the name and the coordinates of the source in the tkds window:

Source : name of the pulsar including B or J # e.g. J1022+1001
RA : hh:mm:ss.sss # coordinates in the pulsar catalogue
DEC : +/-dd.mm.ss.sss
EPOC COORD: J2000

These values will be used in the header of the psrfits file.

Since you have already given the commands `fold` and `cycle 10`, it is not necessary to do it again in the Command field. Instead, you will need to give these commands if you change from search mode to folding mode.

Open a file to write the data by giving the following command in the Command field :

```
> fo f140131_182000_J1022+1001.rf         # change the filename
```

The output name of the file is fyymmdd_hhmmss_sourcename.rf, hhmmss being in UT.

Then click on `GO` to start data acquisition.

To stop data acquisition, you can click on the `STOP` button in tkds or give the "stop" command in the Command field at the bottom of tkds. Since the DFB takes 1 or 2 cycle times to empty its buffers, wait until the DFB status changes from `STOP Requested` to `STOPPED`.

Finally, close the data file by giving the `fc` command.

6) OBSERVING IN SEARCH MODE

Once the values of the attenuations are correctly set (section 4) and the temperature is lower than 70°, you can enter the parameters corresponding to search mode.
Select the correct configuration file, whose name begins with `srch` and is followed by the bandwidth and the number of frequency channels (e.g. `srch_512_128`), and press the `CONFIG` button. Check that the observer (`scicom`) and observer type (`PSR WBPSR`) are correct.

Enter the values for the frequency, bandwidth, rest frequency, whether the frequency is inverted or not, followed by the commands corresponding to search mode. For instance, by following the previous example:

Search mode:

- frequency: `1556.0` # in MHz (in this example, LO=2324 MHz); see Appendix B
- bandwidth: `512.0`
- rest frequency: `1556.0`
- inverted: `NO` # see Appendix B
- commands: # the three first letters of each command are enough

```
> search
> snproducts 1          # number of products to collect (AA, BB polarizations)
> snbits 1              # number of bits with which data are quantized (1, 2, 4 or 8)
> ssamt 0.000125        # sample time in sec
> stconstant 1          # time constant to produce the average bandpass (sec)
> spsub 512             # number of samples per subint (default is 2048)
> sset                  # enable pulsar search set mode
> smfs 1800             # set the maximum file length in seconds (default is 0)
```

Notes:

- `ssamt` : below 125 microseconds, the DFB can start losing packets. In this case, `NOT KEEPING UP` error messages will appear in pdfb3. If this happens, stop the observation, change `ssamt` with a bigger number and do a search set again.
- `smfs n` : the value by default (n=0) means that the file will remain open for the entire observation until you close the file. Otherwise, the file will be closed and a new one is opened after each n second interval (with "k" appended to the filename, incrementing with each new file). It is important to set this parameter for long observations in search mode since the file size is limited at 2 GB at present. The file size depends on the channel number, sampling time, number of bits per sample, and number of polarization products.

Then click on `GO`, wait 30 sec, and click on `STOP` to correctly set the search mode parameters.

The system is now ready to observe. Point the antenna to the source, giving Nuraghe the following command with the correct coordinates in the Operator Input window:

```
> sidereal=J1022+1001,10:22:58.131h,10:01:57.401,2000,neutral
```

In the tkds window, enter :

Source : name of the pulsar including B or J # e.g. J1022+1001
RA : hh:mm:ss.sss # coordinates in the pulsar catalogue
DEC : +/-dd.mm.ss.sss
EPOC COORD: J2000

```
> search
```

```
> fo f140131_182000_J1022+1001.sf
```
write the data on a file; change the filename

The output name of the file is fyymmdd_hhmmss_sourcename.sf, hhmmss in UT.

Then click on `GO` to start data acquisition.

Remember to check the temperature of the DFB: it is necessary to control the alarm light in box AP directly. Moreover, you have to monitor the DFB bandpass in real time in order to detect the presence of RFI and strong sources during the observation (see section 7 dedicated to the quicklook of the dfb bandpass).

Once you completed your observation, data acquisition has to be manually stopped by either clicking on the `STOP` button in tkds or giving the "stop" command in the command field at the bottom of tkds. Since the DFB takes 1 or 2 cycle times to empty its buffers, wait until the DFB status changes from `STOP Requested` to `STOPPED`. Then close the data file by giving the `fc` command.

```
> stop
> fc
```

If you want to observe another source, you can simply change the name of the source and its coordinates in the tkds window, and modify the antenna pointing with the `sidereal` command in Nuraghe, as previously described. You can also change the configuration file and the other parameters (e.g. frequency, bandwidth, `ssampt`, etc). It is not necessary to do again `sset` and a fake observation before observing another source or the same source with different parameters in search mode.

You can directly do the following:

```
> fo f140131_182000_J1022+1001.sf
> go
```
change the filename

To stop it:

```
> stop
> fc
```

On the other hand, if you change from folding mode to search mode, you will have to do everything from the beginning of this section.

7) QUICKLOOK OF THE DFB BANDPASS (real-time monitoring)

During an observation, you can check in real time the bandpass of the DFB and the data flow (frequency domain plots or a selection of a range of frequency channels) using the SPD (Spectra Display for ATNF correlators) graphics display. To do that, in the fourth terminal, give the command `spd`.
In the following, we show some useful SPD commands:

```
> spd
> a              # to display the bandwidth
> ch             # frequency channels in the whole range
> ch 90 400      # channels in the range 90-400
> sel aa,bb      # to check both polarizations
> x              # to change from channel to frequency, or the contrary
> sel bin        # bins in function of channels  (folding mode)
> sel pp11       # time series
```

Note that for `sel bin` and `sel bin`, data are displayed at DM=0.

For a more extensive list of the SPD commands and their usage, see [8].

8) CHECKING THE DATA

Inspection of the data is done through nuraghe-obs2. Login on nuraghe-obs2 by typing :

```
> ssh -CX scicom@nuraghe-obs2
```

The data are downloaded from the pdfb hardware at the end of each cycle on the psrdfb2 machine, in the directory /DATA2/PDFB3_1. This directory is seen in read-only mode from nuraghe-obs2. The predefined environment variable PSRDATA2 points to it.

To check the data, you will have to execute some of the commands in a local directory on nuraghe-obs2 if it does not work in the data directory :

```
> cd DFB/        # create your own subdirectory if needed
```

You can check the parameters of an observation and have a look to the data using the PSRCHIVE software package [9], which offers an extensive range of algorithms and tools for the data analysis of pulsars. See [10] for a description of the basic and advanced functionalities of PSRCHIVE. For the search mode data, you can use `dspsr` [11] plus the PSRCHIVE package or the blind search software packages PRESTO [12] or SIGPROC [13].

a) Checking the parameters of the observation (psredit, vap, and psrstat)

For both search mode and folding mode data, you can use either `psredit` (recommended) or `vap` to check the parameters of the observation (see [14] and [15] respectively for the on-line documentation about these commands). Note that the data file should be closed (with `fc`) before using these commands to avoid any problem, such as undefined parameters. Use `psredit -h` and `vap -h` to see how to use these commands, and `vap -H` to have a full list of parameters able to be queried with `vap`.
A simple use of these commands is:

```
> psredit -c par filename(s)

> vap -c par filename(s)
```

where `par` is a string containing one or more parameter names, separated by commas.

Here are some examples.

```
> psredit -c name,freq J0218+4231_1923.rf  # prints the source name and central frequency
                                             given in tkds

> vap -c asite J0218+4231_1923.rf          # returns "s" for SRT
> vap -nc bw J0218+4231_1923.rf            # returns the bandwidth without header (-n)
> vap -c length J0218+4231_1923.rf         # returns the length of the file
```

You can also use `psrstat` to have a list of information associated with the observation (see [16]).

```
> psrstat J0218+4231_1923.rf
```

b) Inspection of the data in folding mode (psrplot or pav)

For folding mode only, you can also visually inspect the data via `psrplot` (recommended) or `pav`, without changing the content of the observation file. See [17-19] for the on-line documentation about these plotting routines. Type `psrplot -h` and `pav -h` for a full list of options. Each type of plot corresponds to a single-letter code, to which are associated some possible options.

In the case of `psrplot`, you can obtain the list of available plots by writting `psrplot -P`. You can use this program in the following way:

```
> psrplot -p plot [-j jobs] filename(s)
```

where `plot` is the type of plot, and `jobs` correspond to the operation performed on the data before plotting. Additional options are possible (see [17]).

Here are some examples:

```
> psrplot -p D -j FT J0218+4231_1923.rf     # D: pulse phase versus intensity
> psrplot -p G -j TD J0218+4231_1923.rf     # G: pulse phase versus frequency
```

The jobs in the previous example indicate: (F) to sum all frequency channels, (T) to sum all subintegrations, and (D) to dedisperse.

The use of `pav` is slightly different but the result is the same. The type of plot (D, Y, and G for instance) and the operations performed on the data (F, T, p, d, …) are all written after the minus sign.

```
> pav -DFTp J0218+4231_1923.rf          # integrated profile
> pav -YFp J0218+4231_1923.rf
> pav -GTpd -b 4 J0218+4231_1923.rf
```

- plot types:
  - D: pulse phase versus intensity
  - Y: pulse phase versus subint
  - G: pulse phase versus frequency channels

- operations:
  - F: sums all frequency channels
  - T: sums all subintegrations
  - p: sums all polarizations
  - d: dedisperses
  - b (n): sums n adjacent bins

If you do not see the pulsar in your data, do not give up just yet: some strong RFI might be corrupting the data and hiding the signal even of strong pulsars. To remove RFI in both time and frequency domain, you can use `pazi` (see [20]). Type `pazi -h` for the list of options. If the data acquisition is not finished, it is a good idea to copy first the data file and then use pazi in this file to avoid any problem. In any case, since the directory where the data resides is read only, if you want to save the output of pazi, you can create a sym-link:

Example:

```
> cd ~/DFB
> ln -s $PSRDATA2/PDFB3_1/J0218+4231_1923.rf .

> pazi J0218+4231_1923.rf             # folding mode
```

`Pazi` opens two windows corresponding to the integrated profile, and to the data that will be cleaned. One of two plots is interactive and shows the phase versus frequency plot by default. It is on this plot that you can clean the data. We report some useful keys to deal with the interactive window:

- two left clicks: zoom
- "z": to delete a channel in frequency when the cursor is on it

- "t": to switch to the phase versus time plot
- "f": to switch to the phase versus frequency plot
- "d": to disperse and dedisperse
- "s": save
- "q": quit

If you think that the ephemeris you used might have been slightly out of date, you can use `pdmp` to search for the best combination of period and dispersion measure around the catalogue value used to fold your data. Type `pdmp -h` for a full list of options (see [21]).
For instance:

```
> pdmp -pr 0.001 -ps 0.001 -mc 64 J0218+4231_1923.rf
```

9) SWITCHING OFF THE DFB

In order to safely switch off the DFB, the following operations have to be done in the order shown below:

1) Quit tkds by clicking its `QUIT` button.
2) Quit pdfb3. If unsure, do `corkill` then `bcckill`.
3) Close the VNC window.
4) Switch off the DFB: only by the authorized personnel.

NEVER SWITCH OFF THE DFB BEFORE CORRECTLY CLOSING TKDS AND PDFB3.

NOTES

*** About the DFB temperature :**

The DFB suffers of overheating when the running configuration is too computationally demanding usually for bandwidths larger than 512 MHz. In the front panel, there are two leds labelled "TEMP ALERT", one for each board. If it turns RED, this means that the temperature values are above the safety threshold.

All temperature values MUST remain below 70 degrees. If any of them reaches this value, the data acquisition has to be stopped for at least 10 minutes to let the DFB cool down.

If you are observing in folding mode, you have to check that the temperatures are below the safety threshold (70 degrees) on the `F1 DSP BRDs` tab of pdfb3 before re-starting the data acquisition. If you are observing in search mode, you can read the values of the temperatures on the blue rectangular panel of the DFB (situated under the led of the temperature alert), in BOX AP.

It is recommended to avoid as much as possible to switch-off then switch-on the DFB. The interruption of data acquisition should be enough to make decrease the DFB's temperatures.

*** Pulsar catalogue:**

To get the coordinates of a pulsar:

```
> psrcat -all -c "RAJ DECJ" J1012+5307
```

To have the full set of ephemeris for a given pulsar:

```
> psrcat -all -e J1012+5307
```

Psrcat ephemeris files reside in `$PSRCAT_RUNDIR/`. The official database (write protected) is psrcat.db.

If you need to add or update the ephemeris for a pulsar in the DFB version of the catalogue:

```
> ssh -X corr@192.168.200.155
> cd $PSRCAT_RUNDIR
> emacs filename.db
```

In filename.db, insert the ephemeris of the pulsar you want to observe following this template:

PSRJ …
RAJ …
DECJ …
F0 …
DM …
...
@-- # to indicate the end of the ephemeris of a pulsar

`> ln -s filename.db ./obsnn.db` # where ***nn*** is a number between 00 and 99

Note that psrcat checks for the file in a numerical order, and it gives priority to the files with the highest numbers, that is, if in both symbolic links obs90.db and obs99.db, there is an entry for B1937+21, it will take the ephemeris from obs99.db. Psrcat does not check for files with a number higher than 99.

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[19] pav : http://psrchive.sourceforge.net/manuals/pav/

[20] pazi : http://psrchive.sourceforge.net/manuals/pazi/

[21] pdmp : http://psrchive.sourceforge.net/manuals/pdmp/

APPENDIX A: Configuration files at SRT

Here is the list of the configuration files currently available at SRT for search and folding modes. Note that the pdfb3 files (dual systems) do not currently work.

Search mode :

srch_1024_512.cfg
srch_256_1024.cfg
srch_256_128.cfg
srch_256_512.cfg
srch_512_128.cfg
srch_64_256.cfg
srch_64_512.cfg

Folding mode :

pdfb4_1024_1024_1024.cfg
pdfb4_1024_1024_1024_new.cfg
pdfb4_1024_1024_2048.cfg
pdfb4_1024_1024_256.cfg
pdfb4_1024_1024_512.cfg
pdfb4_1024_128_1024.cfg
pdfb4_1024_128_2048.cfg
pdfb4_1024_128_512.cfg
pdfb4_1024_256_1024.cfg
pdfb4_1024_256_2048.cfg
pdfb4_1024_256_256.cfg
pdfb4_1024_256_512.cfg
pdfb4_1024_512_1024.cfg
pdfb4_1024_512_2048.cfg
pdfb4_1024_512_512.cfg
pdfb4_1024_64_1024.cfg
pdfb4_1024_64_2048.cfg
pdfb4_1024_64_512.cfg
pdfb4_128_64_1024.cfg
pdfb4_128_64_512.cfg
pdfb4_2048_1024_1024.cfg
pdfb4_2048_1024_128.cfg
pdfb4_2048_1024_2048.cfg
pdfb4_2048_1024_256.cfg
pdfb4_2048_1024_512.cfg
pdfb4_2048_256_1024.cfg
pdfb4_2048_256_2048.cfg
pdfb4_2048_256_512.cfg
pdfb4_2048_512_1024.cfg
pdfb4_2048_512_2048.cfg
pdfb4_2048_512_512.cfg

pdfb4_256_1024_1024.cfg
pdfb4_256_1024_2048.cfg
pdfb4_256_1024_512.cfg
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pdfb4_256_256_512.cfg
pdfb4_256_64_1024.cfg
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pdfb4_512_1024_1024.cfg
pdfb4_512_1024_2048.cfg
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pdfb4_512_128_1024.cfg
pdfb4_512_128_2048.cfg
pdfb4_512_128_512.cfg
pdfb4_512_16_2048.cfg
pdfb4_512_256_1024.cfg
pdfb4_512_256_2048.cfg
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pdfb3_2048_1024_512.cfg
pdfb3_2048_256_1024.cfg
pdfb3_2048_256_2048.cfg
pdfb3_2048_256_512.cfg
pdfb3_2048_512_2048.cfg
pdfb3_2048_64_2048.cfg
pdfb3_256_1024_2048.cfg

pdfb3_256_256_1024.cfg
pdfb3_256_256_2048.cfg
pdfb3_512_1024_1024.cfg
pdfb3_512_1024_2048.cfg
pdfb3_512_128_2048.cfg
pdfb3_512_128_512.cfg
pdfb3_512_256_1024.cfg
pdfb3_512_256_2048.cfg
pdfb3_512_256_512.cfg
pdfb3_512_32_512.cfg
pdfb3_512_512_2048.cfg
pdfb3_512_512_512.cfg
pdfb3_512_64_1024.cfg
pdfb3_512_64_2048.cfg
pdfb3_512_64_512.cfg
pdfb3s_2048_1024_2048.cfg
pdfb3s_2048_256_2048.cfg
pdfb3s_512_256_1024.cfg
pdfb3s_512_256_2048.cfg

APPENDIX B: Central frequency in L- and P-bands, frequency inverted or not?

1) L-band

The down-conversion chain of the L-band receiver (1.3 - 1.8 GHz) at SRT has been designed so that the frequency order becomes inverted after the signal down-conversion. The sky frequency (equal to the LO one) is converted to the zero frequency, and a generic frequency (LO–Δv) is converted to +Δv. For a 1024 MHz bandwidth, as in the case of the DFB, the down-converted lower and upper limits are, respectively, $LO_{(sky)}$ => 0 MHz and $(L0 - 1024)_{(sky)}$ => 1024 MHz, as illustrated in Figure 7.

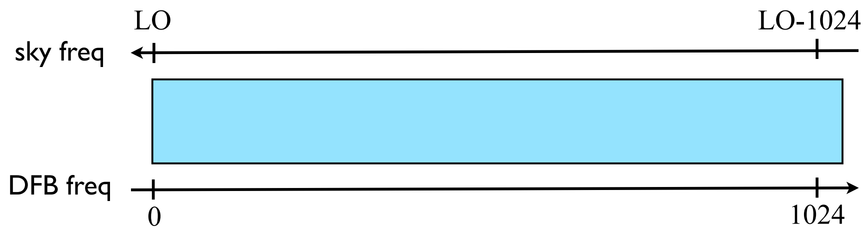

Figure 7: Scheme of the sky frequency and the DFB band (1024 MHz). The frequencies are in MHz.

The LO frequency of this system is generally set to 2316 MHz (LEAP frequency) or 2324 MHz (VLBI frequency). Hence, the 2316 or 2324 MHz frequency is converted to 0 MHz, and either 2316-1024 = 1292 MHz or 2324-1024 = 1300 MHz is converted to 1024 MHz. The 1300-1800 MHz band (L-band) falls into the upper half of the DFB working band, as shown in Figure 8. This, in principle, requires a DFB bandwidth of 1024 MHz.

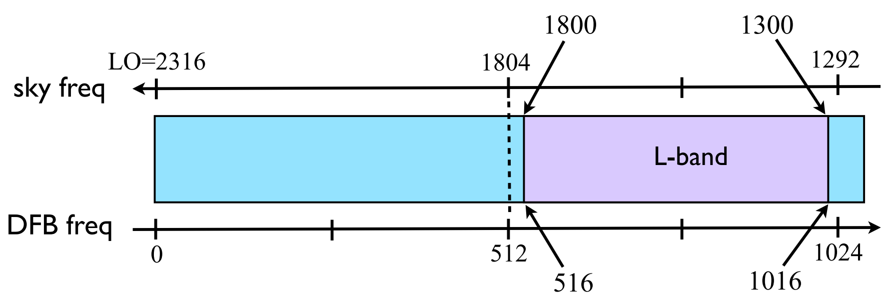

Figure 8: Position of the L-band along the DFB working band for a LO value of 2316 MHz.

However, because of the mathematical properties of signal sampling, namely the aliasing effect, if a 512 MHz bandwidth is set, the L-band is mirrored in the lower half of the DFB working band (see Figure 9).

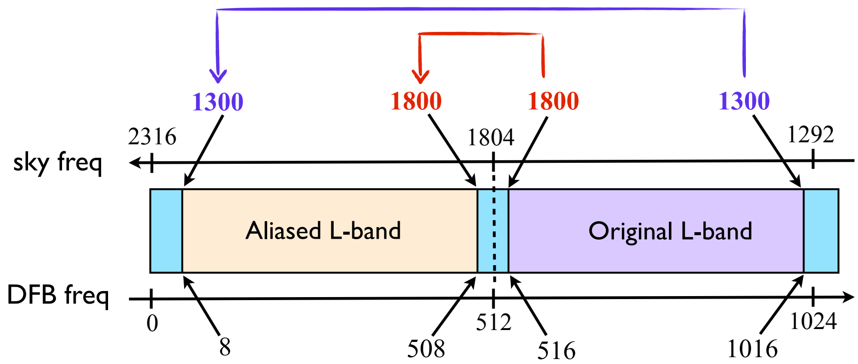

Figure 9: Aliasing effect when a 512 MHz bandwidth is selected.

The central frequency is inside the frequency interval 1292-2316 MHz using the previous LO value, and depends on the choice of the observing bandwidth (BW=8, 16, 32, up to 1024 MHz). This determines the Nyquist windows (same width than the chosen bandwidth) inside the DFB bandwidth, and whether the bandwidth will be inverted or not. Since the original DFB band is inverted, the central frequency placed at the center of any given Nyquist window will be "inverted" if the frequency is in an even Nyquist window, or "not inverted" in the case of an odd Nyquist window.

The central frequency can be calculated in the following way:

$$F_c = LO - BW*(n+1/2), \text{ with n an integer from 0 to } (1024/BW-1).$$

The choice of n depends on the range of L-band frequencies, since the central frequency and the observing bandwidth have to be inside L-band to avoid any aliasing effects.

In the following, we show some examples to better clarify when and how these choices can be done.

a) To observe along a 1024 MHz bandwidth, the central frequency has to be set to 1804 MHz considering LO=2316 MHz, and the "INVERTED FREQ" parameter has to be set to YES (n = 0 corresponds to the first Nyquist window).

b) For a bandwidth of 512 MHz, the central frequency has to be set to 2060 MHz (with n = 0 and corresponding to the first Nyquist window) or 1548 MHz (with n =1; second Nyquist window). Since 2060 MHz is outside the L-band, the chosen value will be F_c = 1548 MHz. This value is inside the second Nyquist window, therefore the frequency will not be inverted.

c) Let us now consider a different LO value, e.g. 2000 MHz. If a bandwidth of 512 MHz is set in the DFB, the sky frequencies from 1488 to 1300 MHz would be reflected and summed to the frequencies from 1488 to 1676 MHz, and aliasing effects on the sampled signal would appear in the recorded data (Figure 10). This is because the receiver bandwidth does not entirely fall inside the half bandwidth of the DFB. Consequently, in such a situation it is mandatory to select a bandwidth of 1024 MHz, "INVERTED FREQ": YES, and the resulting central frequency is 1488 MHz.

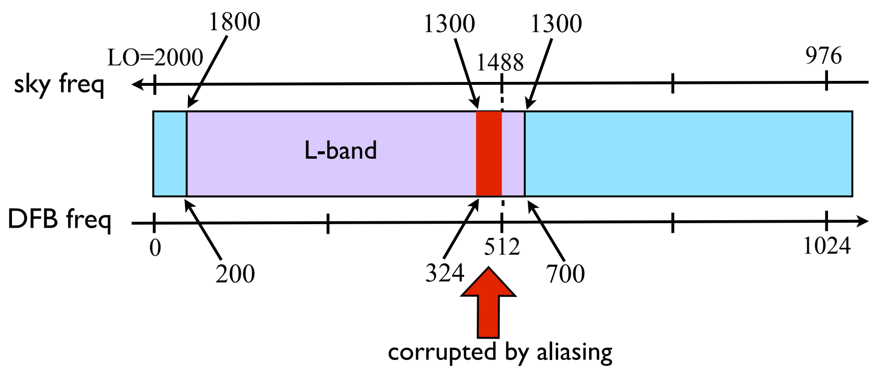

Figure 10: Position of the L-band along the DFB working bandwidth for a LO value of 2000 MHz. Aliasing effects are visible when a bandwidth of 512 MHz is selected.

2) P-band

Contrary to L-band, P-band (305 - 410 MHz) is not inverted with respect to the DFB. Moreover, it is directly inside the DFB band (0 – 1024 MHz), as illustrated in Figure 11, so the use of a local oscillator is not necessary.

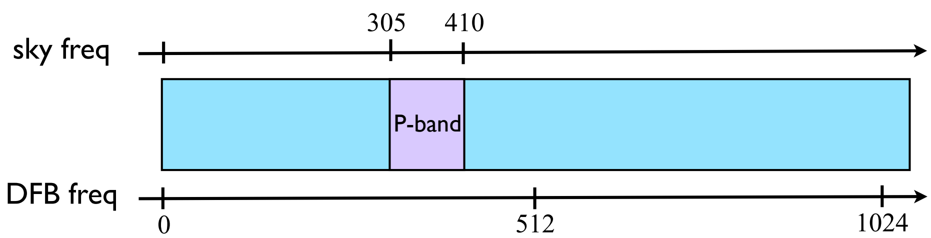

Figure 11: Position of the P-band (purple area) along the DFB.

The determination of the central frequency and whether the bandwidth will be inverted or not depend only on the choice of the bandwidth. The DFB band is divided into X sub-bands of the chosen bandwidth (e.g. 2 sub-bands of 512 MHz, or 4 sub-bands of 256 MHz). Each sub-band corresponds to a Nyquist window. The P-band corresponds to a certain Nyquist window. The central frequency is simply determined as the center of this Nyquist window. The frequency will be non-inverted if the Nyquist window is even, and inverted in the case of an odd Nyquist window, beginning with 0 for the first Nyquist window. We show two examples below.

a) We first consider a bandwidth of 256 MHz. The DFB band is divided into 4 sub-bands of 256 MHz. The P-band is in an odd Nyquist window (n°1). The central frequency is 384 MHz, with the bandwidth inverted (see Figure 12).

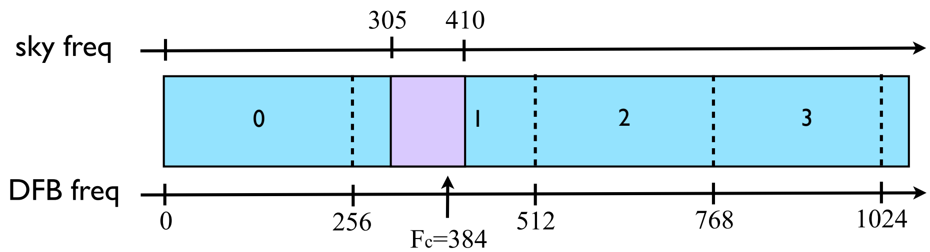

Figure 12: Position of the P-band (purple area) considering a bandwidth of 256 MHz. The numbers (0-4) indicate the Nyquist windows, and Fc is the central frequency.

b) Considering now a bandwidth of 128 MHz, the DFB band will be divided into 8 sub-bands. The P-band is between the n°2 and n°3 windows. The central frequency corresponds to the center of the n°2 window since the P-band is mostly situated in this window, so Fc=320 MHz. Note that the signal will be filtered at 384 MHz, and in this case, the real observing band will be 79 MHz. The bandwidth will be not-inverted (even Nyquist window).

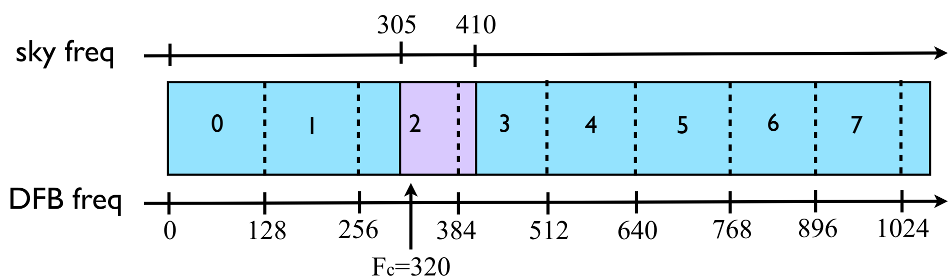

Figure 13: Position of the P-band considering a bandwidth of 128 MHz. The numbers (0-7) indicate the Nyquist windows, and Fc is the central frequency.

APPENDIX C: Tips for choosing the tkds parameters

Indicative tables in folding and search modes in order to help the user choose between the possible configuration files and parameters to set in tkds. For more information, see :
http://www.parkes.atnf.csiro.au/observing/utilities/pulsar_sched/configs.html

Folding mode :

The choice of the configuration file depends mainly on the period of the pulsar, the dispersion measure (DM), which has a smearing effect on the signal, and the spectral resolution one would like to reach. In general, it is recommended to select a large bandwidth to have the maximum signal. However, in the case of large DM, it is convenient to increase the spectral resolution and so to increase the number of frequency channels and/or decrease the bandwidth. For ms pulsars, it is a good choice to select fewer pulsar phase bins. On the other hand, for longer pulsar periods, the pulsar phase bins will be larger.

The following table reports lower limits on the period of the pulsar (P_{min}), the indicative DM at which the smearing becomes visible (comparable or greater than the intrinsic pulse width ; values estimated considering a pulsar period of 2 ms and a smearing of 10%), the DM smearing (δt_{DM}) calculated for DM=1000 for C-band, DM=100 for L-band, and DM=10 for P-band, the configuration file, the central frequency, the bandwidth, and the fact that the bandwidth will be inverted or not.

The DM smearing can be approximated by :

$$\delta t_{DM} \approx 8.3 \times 10^3 \frac{\delta \nu}{\nu^3} DM \quad (sec)$$

$$\delta \nu = \frac{BW}{N_{chan}} \quad (MHz)$$

with BW the bandwidth in MHz, N_{chan} the number of frequency channels, ν the central frequency in MHz, and DM the value of the DM in cm^{-3} pc.

	P_{min} (ms)	**DM** (cm^{-3} pc)	**δt_{DM}** (ms)	**Config-file** (pdfb4_bins_bw_chan.cfg)	**Central freq.** (MHz)	**Bandwidth** (MHz)	**Inverted ?**
C	0	any	0.0425	pdfb4_256_1024_512	7312	1024	no
	0.26	any	0.0425	pdfb4_512_1024_512	7312	1024	no
L	0.52	< 100	0.224	pdfb4_512_512_512	1548	512	no
	0	200 - 300	0.112	pdfb4_512_512_1024	1548	512	no
	2.05	300 - 400	0.0559	pdfb4_512_512_2048	1548	512	no
P	1.03	< 3	0.733	pdfb4_512_256_512**	384	256	yes
	1.03	< 5	0.366	pdfb4_256_256_1024	384	256	yes
	2.05	< 10	0.183	pdfb4_256_256_2048	384	256	yes
	0	20 - 50	0.158	pdfb4_512_128_2048	320	128	no

** configuration adapted for long period pulsars, or ms pulsars with DM < 10.

Notes :
C-band (5.7-7.7 GHz) : considering LO = 6800 MHz
L-band (1.4-1.8 GHz) : with LO=2316 MHz
P-band (305-410 MHz) without LO

Search mode :

In the following, we present some possibilies for the search mode :

	Period pulsar	**Config-file** (srch_bw_chan.cfg)	**Central freq.** (MHz)	**Bandwidth** (MHz)	**Inverted ?**
C	all	srch_1024_512	7312	1024	no
L	ms pulsars*	srch_1024_512	1804	1024	yes
	long period or ms pulsars**	srch_512_128	1548	512	no
P	all	srch_256_1024	384	256	yes
	long period	srch_256_512	384	256	yes

* ms pulsars with DM > 50 (blind search at low latitudes or timing of binaries with poorly known ephemeris)
** ms pulsars with DM < 50

At present, the “srch_512_512” configuration file is not available at SRT. However, in a near future, it will be added to the list of configuration files. It will be useful, in particular, for L-band observations, for the detection of new ms pulsars.

In general, C-band is used for the observation of magnetars, using the largest bandwidth (1024 MHz).

P-band is of great interest for the simultaneous observations with L-band, in order to determine the DM with precision. At present, it is not possible with the current state of the DFB.