Operating Manual

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Abstract

This manual describes the operation of the radio telescope kit used for radioastronomy observations. It contains a description of how to use the hardware and the software of the telescope.

The kit is divided into outdoor and indoor units. The outdoor unit comprises the dish mount, a 1.20 m offset antenna with low noise block, and an azimuth and elevation positioning motor. The main part of the indoor unit is a satellite measurement receiver, which is used to determine the signal strength. The measured signal strength is transmitted to a standard PC which records this data. A dedicated RadioAstro application (software with graphical user interface) is used for controlling the receiver settings, acquiring the measurement data, visualising the measurement results and for controlling the dish positioning system.

The free software "Le Cartes du Ciel" is used for calculating the correct positions of astronomical objects. Data postprocessing and visualisation are provided by Microsoft Excel.

Typical measurement tasks will be explained in detail with the use of examples.

A description is included of how the application software may be extended by advanced students.

Contents

Terms and Abbreviations

AC	Alternating Current
API	Application Programming Interface
AWG	American Wire Gauge
AZ	Azimuth
COM	Communications
CRT	Cathode Ray Tube
DC	Direct Current
DIN	Deutsches Institut für Normung
DLL	Dynamic Link Library
EL	Elevation
FM	Frequency Modulation
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
IF	Intermediate Frequency
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LNB	Low Noise Block
MFC	Microsoft Foundation Class
N/A	Not Applicable
NICAM	Near Instantaneous Companded Audio Multiplex
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-shift Keying
S	Surge
Sat	Satellite
SDK	Software Development Kit (Microsoft Platform)
GUI	Graphical User Interface
PC	Personal Computer
TCP/IP	Transmission Control Protocol/Internet Protocol
TV	Television
UTC	Coordinated Universal Time
LCD	Liquid Crystal Display
USB	Universal Serial Bus
VAT	Value Added Tax
VHF	Very High Frequency

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1   Installation of RadioAstro Software

The RadioAstro software is an application with Graphical User Interface (GUI), which allows the user to control and observe all tasks for the Radio Telescope Kit. The free astronomy software "Le Cartes du Ciel" can be used in addition for the planning of observations. In the following sections you will learn how to install the software on your PC. If the software is already installed, you can skip this chapter and go directly on to Chapter 2.

1.1   PC Requirements

As a first step you should have a close look on your PC. No special PC or laptop is required for using the RadioAstro software. The following fulfilled requirements are sufficient:
- Operating system: Microsoft Windows 2000 or XP
- Microsoft Excel would be a good feature to provide further data processing and visualisation
- Graphics resolution at least 1024 * 768
- Hard disk at least 30 MByte
- Two serial ports (RS232 / COM-Ports) for controlling the positioner and the measurement receiver

    If the PC is not equipped with two serial ports, one or two USB-to-RS232-converters may be used instead. These converters are commonly available at most hardware stores.

1.2   Software installation

There are two versions implemented of RadioAstro software; a Visual C++ and a Visual Basic application. Both versions provide the same functionality and almost the same look and feel. If you don't plan to modify or extend the application you should use the Visual C++ application. If you would like to extend the programs by yourself you should use the appropriate version, depending on your favorite programming language (Visual Basic or Visual C++). The installation of the freeware "Le Cartes du Ciel" for calculating the coordinates of astro objects (Sun, Moon, ..) is also recommended.

1.2.1 Installing the Visual C++ application

Use Windows Explorer to copy all files into your chosen directory. Your Explorer window should look like in Figure 1.
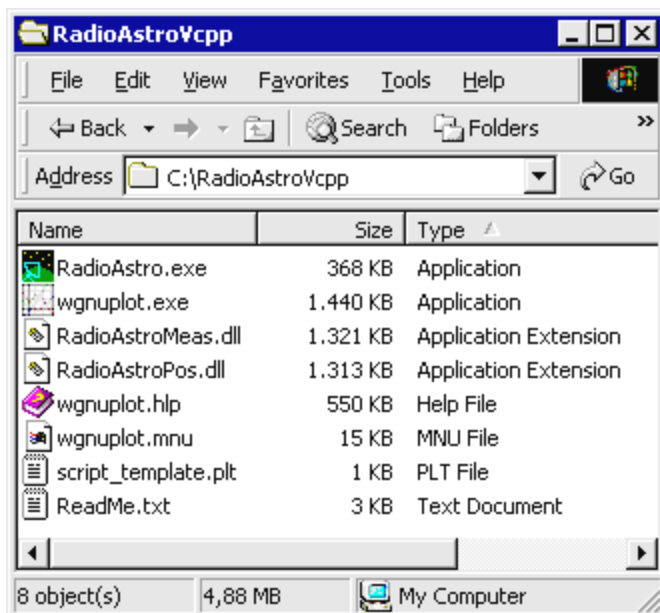
Figure 1 Installing the RadioAstro software (Visual C++ application)

Create a shortcut icon on the desktop for fast starting of the RadioAstro software, by selecting "RadioAstro.exe" with right hand mouse button in Windows Explorer ➔ Send To ➔ Desktop.

1.2.2 Installing the Visual Basic application (optional)

You need this installation only if you do <u>not</u> install the Visual C++ application (see section above).
Use the Windows Explorer to copy all files and directories to your PC hard drive. Your Explorer window should look like Figure 2. Don't forget the mandatory resource directory "res".
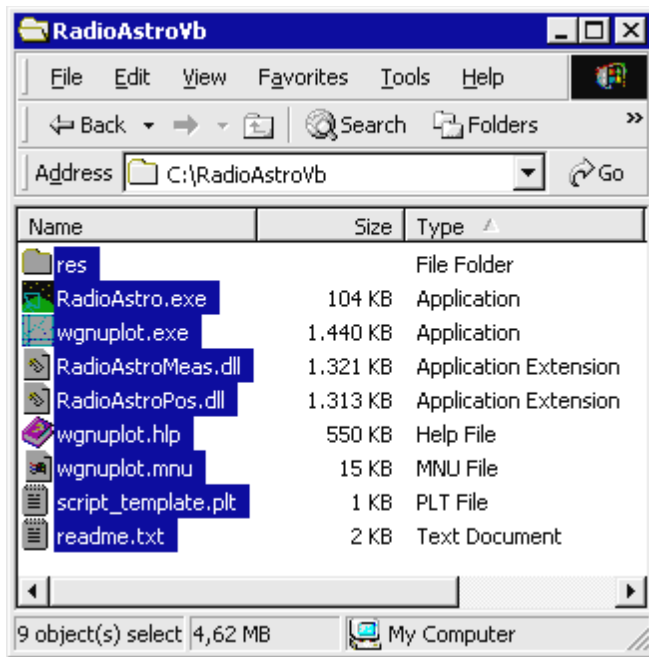
Figure 2 Installing the RadioAstro software (Visual Basic application)

Create a shortcut icon on desktop for fast starting of the RadioAstro software: select "RadioAstro.exe" with the right hand mouse button in Windows Explorer ➔ Send To ➔ Desktop.

1.2.3 Installing "Le Cartes du Ciel"

Download the most recent version from the following weblink. If you don't have access to the internet you may use also the version provided on the RadioAstro CD.

http://astrosurf.com/astropc/cartes/index.html

On this page click on the English banner ➔ Download, and then load the "Basic package" and optionally a language file of your favoured language. The following languages are available: English, French, German, Greek or Portuguese.

You may then run the installation program by starting the "cdcbase.exe" (e.g. double click on icon in Windows Explorer). The optional language file must be installed in the same manner.

2 Using the Radio Telescope

In this section you will learn how to plan and execute observations. First, an overview is given on the hardware in the control room and how the telescope is switched on and off. You will learn how the RadioAstro software is used to control the telescope, how to plan an observation with "Le Cartes du Ciel", and how to perform postprocessing and visualisation of the observation results.

2.1 Overview on the control room
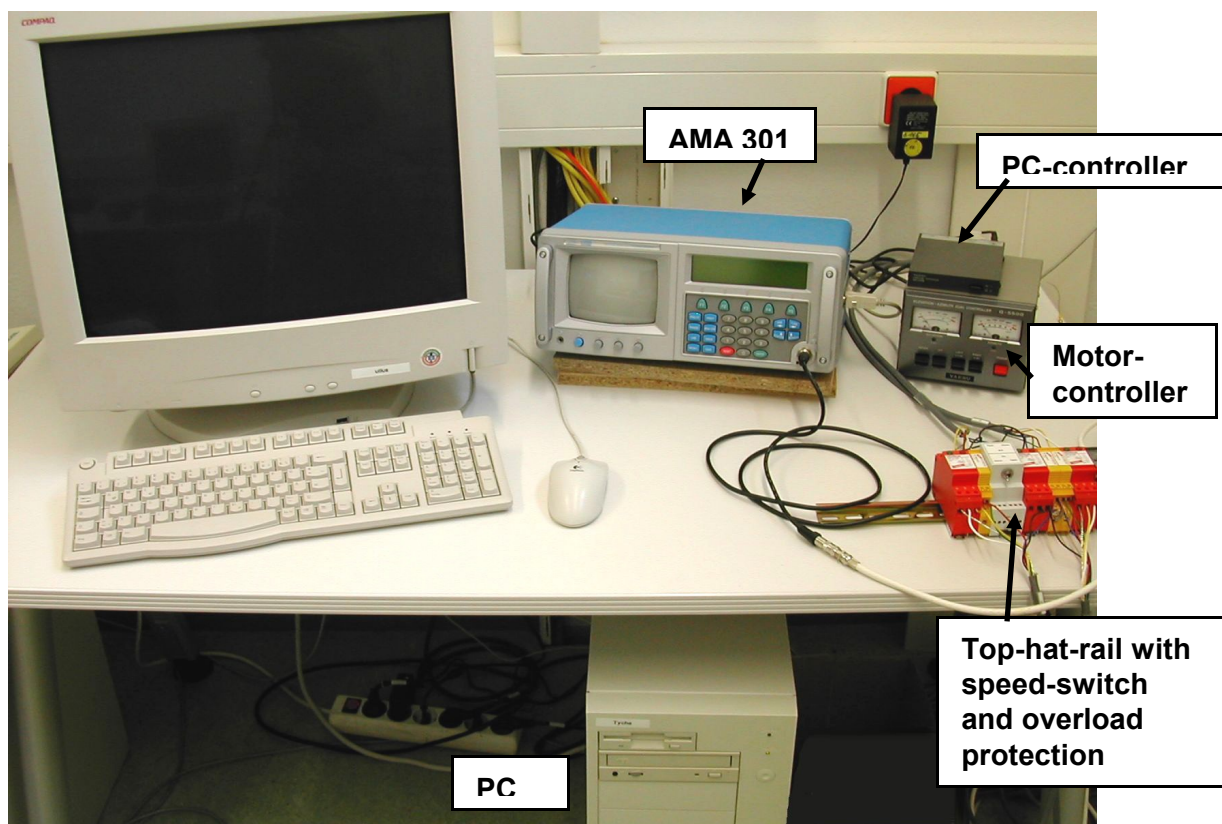
Figure 3 Control room (Indoor Unit)

Figure 3 shows the control room of the telescope. The PC is used to plan and execute observations. It controls the receiver AMA 301. The PC-controller is the interface between the PC and the motor controller, which drives the antenna motors of the outdoor unit. The top-hat-rail contains the speed-switch as well as the over voltage protection.

2.2   How to switch the telescope on and off

The telescope consists of separate devices. This section shows the sequence in which the devices must be powered on to ensure correct operation. This section also shows how to switch the telescope off after an observation has been completed.

Switch on

1. Switch on the receiver AMA 301
2. Switch-on the PC
3. Start the RadioAstro Software
4. Switch-on the Motor-Controller
   Attention! Always start the motor-controller **before** the PC-controller
5. Switch-on the PC-Controller
6. Wait 10 minutes for the receiver to warm up.

The telescope is now ready for operation.

Switch-off

There is no special order required to switch-off the telescope:
- Switch-off the AMA 301 receiver, the PC-controller and the motor-controller
- Close the Radioastro and "Le Cartes du Ciel" applications on the PC
- Shut down the operating system and switch-off the PC, if it is not in use for other tasks
- Unplug the 12V AC-DC adapter for the Computer Control Interface (GS-232B). It may not be switched off.
- Check that all devices of the telescope are off

2.3 Planning and execution of observations

In the following sections you will learn how to use the software of the telescope. This includes the control software "RadioAstro", "Le Cartes du Ciel" for the planning of observations, and data postprocessing with Microsoft Excel.

2.3.1 Working with the RadioAstro software

Figure 4 shows the Graphical User Interface (GUI) of the RadioAstro software, which allows the user to control and observe all tasks for the Radio Telescope Kit. You should see this window after starting the RadioAstro software.

The upper part of the main window corresponds to the positioning system. The lower part corresponds to the measurement receiver. In general, both controller parts work independently from each other.
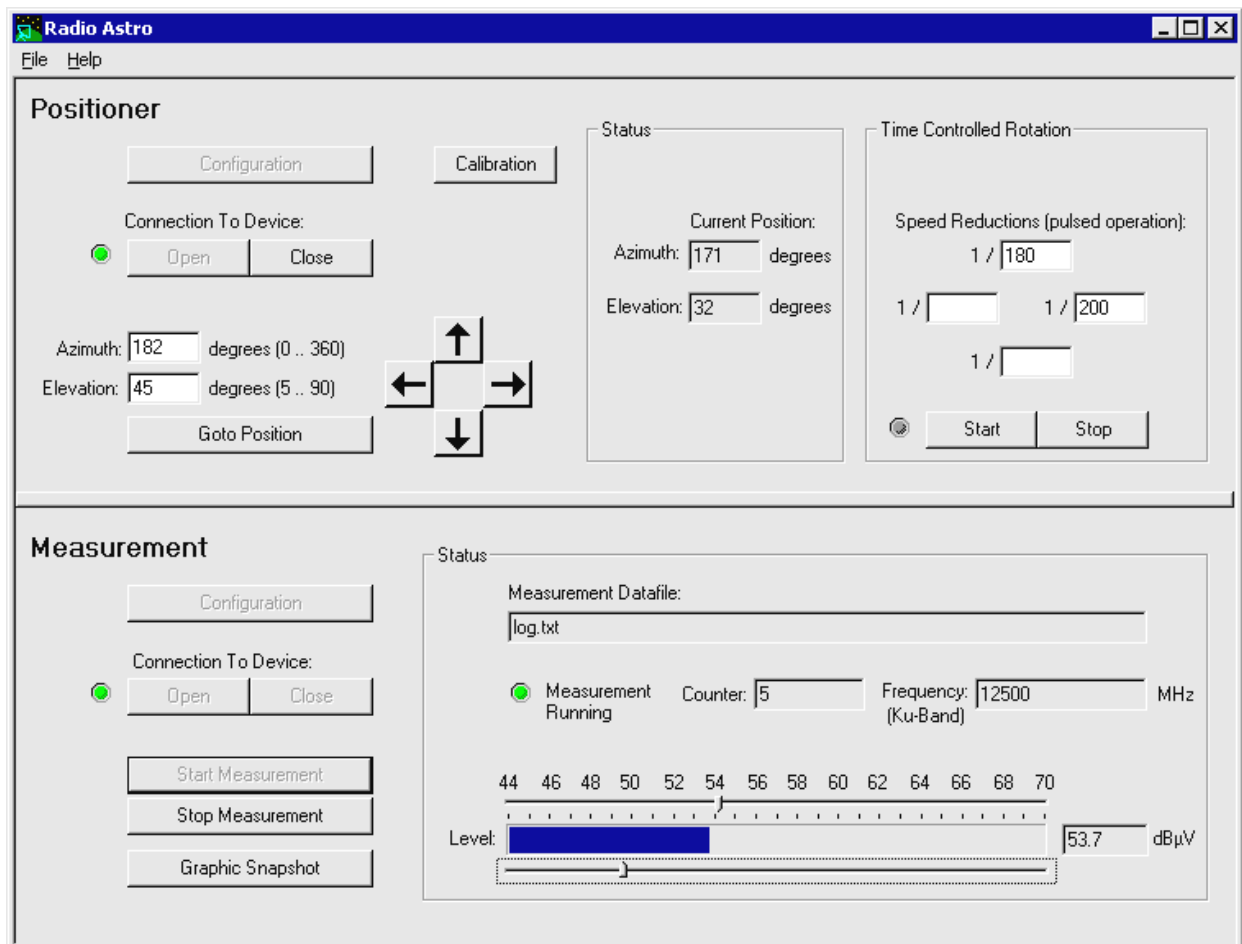
Figure 4 Graphical User Interface of RadioAstro software (Main window)

2.3.1.1 Positioner subwindow

See Figure 5 for a view of the positioner subwindow.
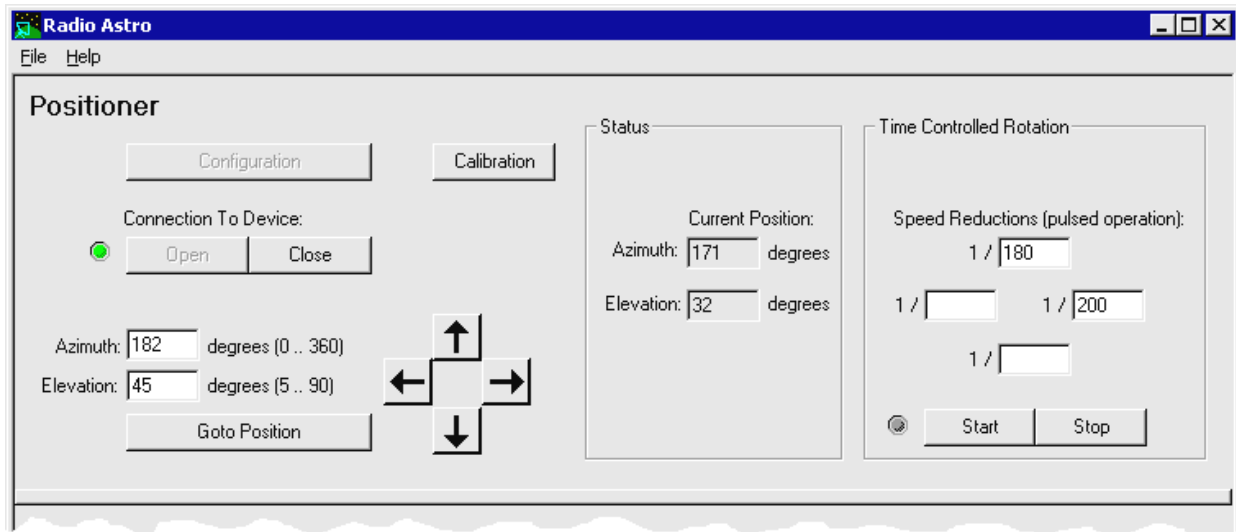
Figure 5 Positioner Subwindow

Configuration:
Before starting normal operation, the configuration parameter (COM-Port) should be checked or modified. Press the button "Configuration" to call up a subwindow where the current configuration parameter is displayed (Figure 6).
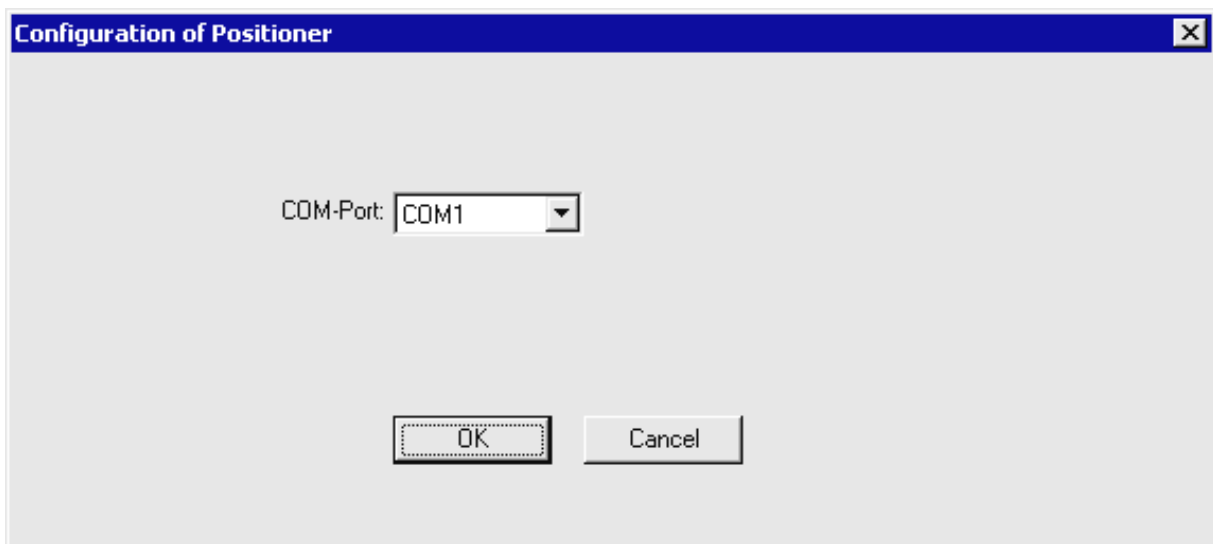
Figure 6 Configuration of the Positioner

If needed, select a new COM-Port number of the PC from the list. The new setting becomes valid after confirmation with the "OK" button, which also closes the subwindow.

Normal Operation:

Before opening the connection you should check if all necessary cables connecting the hardware (Rotators ⇔ Rotator Controller ⇔ Controller unit ⇔ PC) are plugged in and all the devices are switched on.
Then establish the connection to the positioning system by pressing the "Open" button.
The current AZ/EL-position is displayed on the right side of window if connection is established correctly and all is working properly.
See "Troubleshooting" section below if you don't get this behaviour.
With this display function, it is possible to observe the real positioner movements at all times.

Move the positioner directly by inputting values for the new azimuth and elevation angles.
Press the "Goto Position" button to execute the command. It takes some seconds until the positioner has moved to the new position, depending on how much the dish must move compared to its previous position.
With the four arrow keys, the position may be changed incrementally in all directions.
Depending on the settings and direction, the rotation speed is as specified in Table 1:

Speed control switch setting	Direction	Raw rotation speed [°/s]
fast	AZ	6
fast	EL	2.5
slow	AZ	0.6
slow	EL	0.2

Table 1: Speed Control Switch Settings to Define Rotation Speed

Time Controlled Rotation:
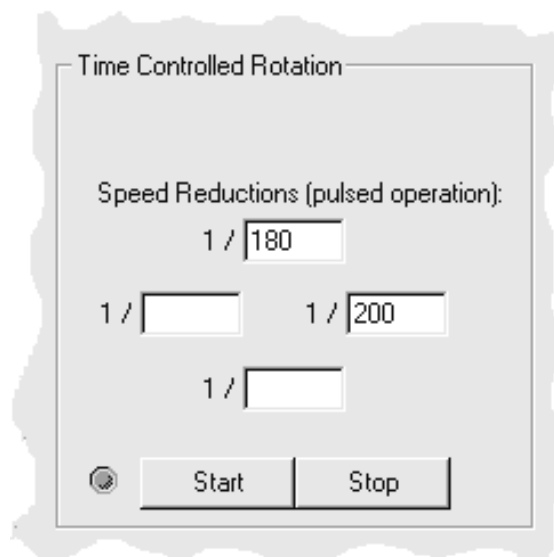
Figure 7 Time Controlled Rotation subwindow

With this subwindow (Figure 7) it is possible to control automatic rotation at very slow constant speed for tracking purposes (e.g. tracking the movement of the Sun).
Reduce the speed of the rotators by selecting "slow" speed with the two switches (AZ and EL) on the speed control switch, mounted on the top hat rail.

Define additional speed reduction values (if necessary) in the text fields for the corresponding direction.
Speed reduction values result in pulsed movements (0.5s active periods) of the rotators to achieve the desired average speed.
Start the slow speed movement by clicking on the "Start" button.
Stop the slow speed movement when required by clicking on the "Stop" button.

What does the speed reduction values (s_{red}) mean?
The following relation may be used for calculating the reduced rotation speed:

$$v_{red} = \frac{1}{s_{red}} v_{orig}$$

v_{orig} Original rotation speed in AZ direction (°/s)

s_{red} Speed reduction value (as specified in user interface)

v_{red} Reduced (resulting) rotation speed (°/s)

Let's do an example for illustration:

with v_{orig} = 0.6 °/s and s_{red} = 100 we get a reduced speed of $v_{red} = \frac{1}{100} 0.6 °/s$

or

v_{red} = 0.006 °/s

This value is only a raw estimation, and must be calibrated further as described in the section on "Automatic Sun tracking".

Where do the correct values for azimuth and elevation (EZ/EL) come from?
To answer this question, see the section below on "How to work with *Le Cartes du Ciel*".

Calibration:
For first operation and after long non-active periods, a calibration of the controller unit is necessary. See the separate Assembly Manual for details.

Ending the operations:
With the "Close" button the connection between RadioAstro software and positioning system will be disconnected.

2.3.1.2 Measurement subwindow

See Figure 8 for an image of the measurement subwindow.
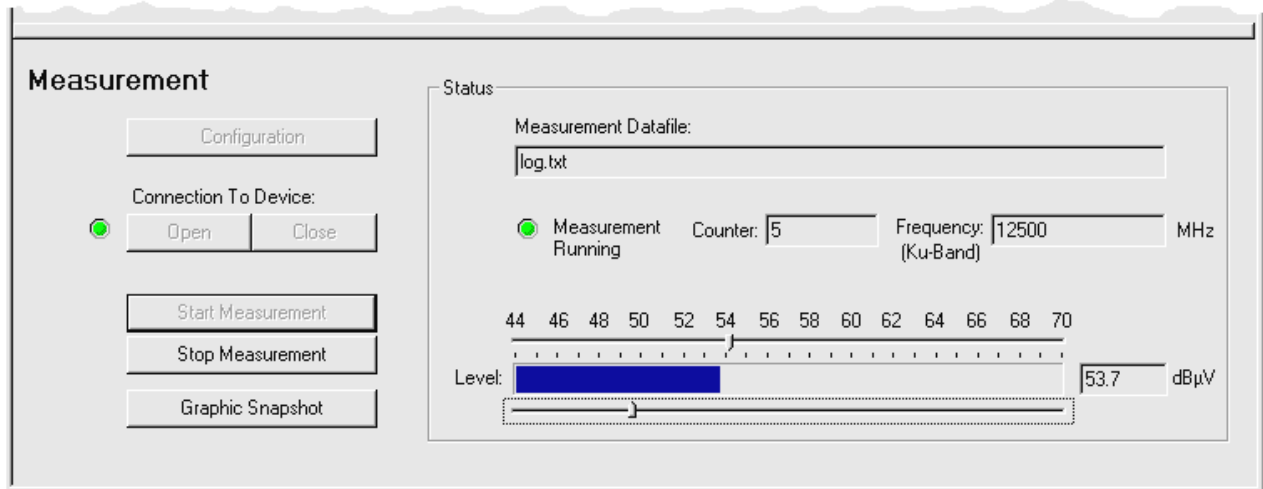
Figure 8 Measurement subwindow

Configuration:
The configuration parameters should be checked or modified before starting operation.
Press the button "Configuration" to call up a subwindow where the current configuration
parameters are displayed (Figure 9).
"COM-Port" specifies the serial port of the PC to which the measurement receiver is
connected with. At "Measurement Datafile", specify a target location for the measurement
log file.
The switch-box below defines if next measured data will be appended to existing
measurement data file or not.
Then follow the receiver settings to define the frequency, band (high or low) and polarisation
(horizontal or vertical).
Notice the calculated value for SAT-IF which is only be displayed when all receiver settings
are consistent.

The configuration parameters may be modified and become valid after confirmation with the
"OK" button, which also closes the subwindow.
The receiver device will be configured with the specified values once an actual measurement
has been started.
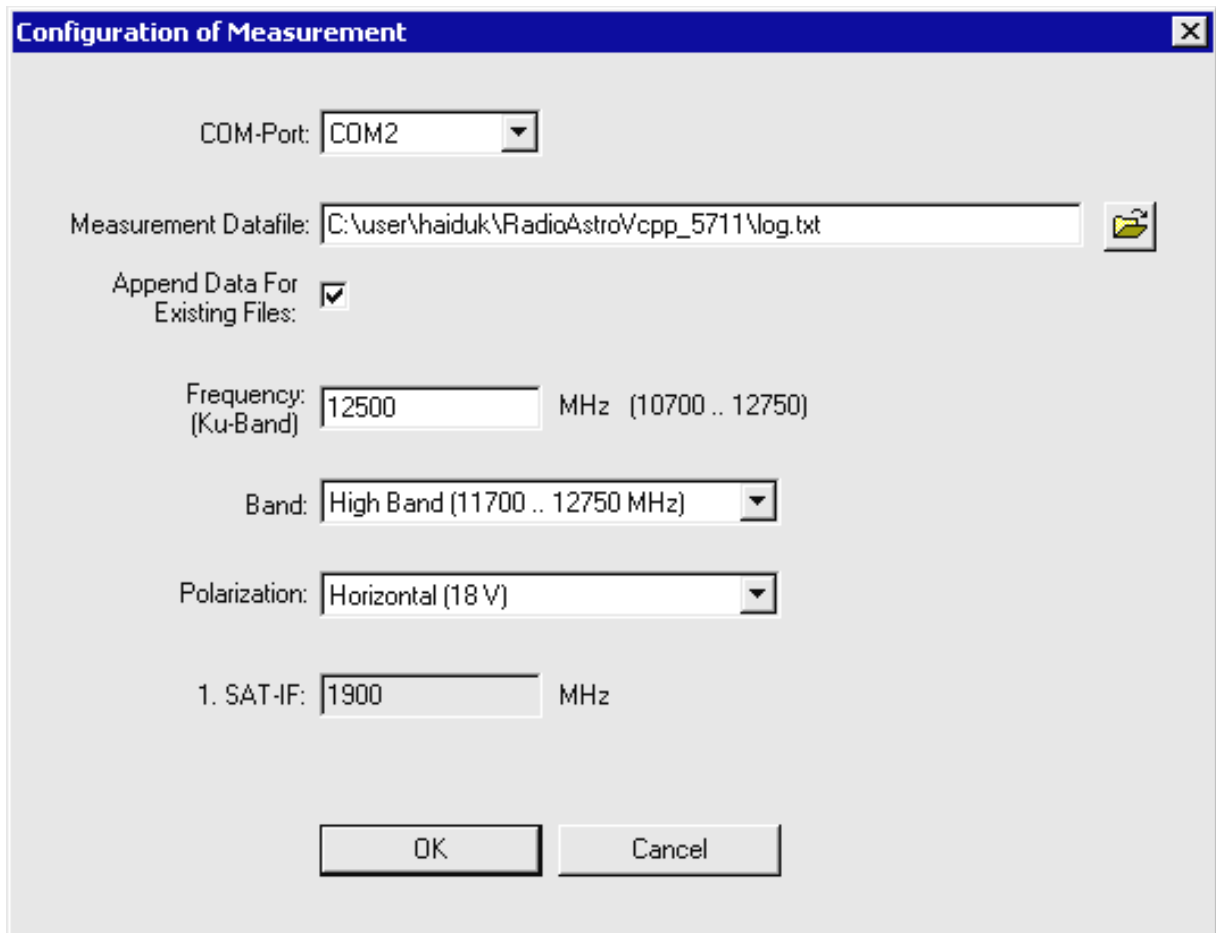
Figure 9 Configuration of measurement

Normal operation:
Before opening the connection you should check if the necessary cables connecting the PC with the measurement receiver are plugged in (LNB ⇔ receiver with coax cable and receiver ⇔ PC with RS232 cable).
Check that the measurement receiver is switched on.
Establish connection between PC and measurement receiver by clicking on the "Open" button.
Click on the the "Start Measurement" button to configure the receiver and to start a continuous measurement.
The currently measured input levels will be transferred from the receiver, stored in the specified measurement datafile, and displayed on the lower right side in the window.

The first two rows of the measurement datafile contain the receiver settings and start time of measurements (Figure 10). Then come rows of the datafile contain time-stamped receiver levels (measurement points).

```
#Freq.= 12100 MHz, SAT-IF= 1500 MHz, High Band, Vertical Polar.
#Start at: 4.3.2005 14:28:55
14:29:05 59.5
14:29:08 59.4
14:29:12 59.4
14:29:16 59.4
14:29:20 59.4
14:29:24 59.3
14:29:27 59.3
```

Time Stamp

Level [dBµV]

Figure 10 Contents of Measurement Datafile

The status subwindow (Figure 11) provides the following information:
- Measurement Datafile: Logfile with time-stamped receiver level values
- Measurement Running: Status LED (green if measurement is running)
- Counter: Incremental counter which counts the measurement cycles since start of measurement (about one measurement in 3.5s)
- Frequency: Currently used input frequency
- Level: Bargraph and numeric display of current receiver level in dBµV
- Two sliders: For use as markers to keep in mind special positions e.g. minimum and maximum receiver level).
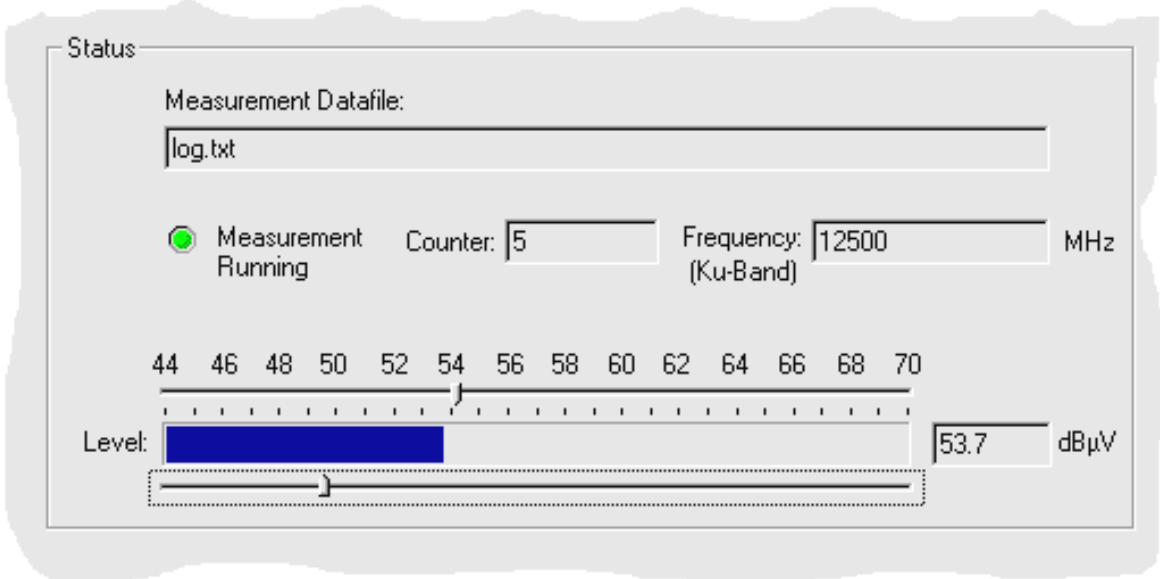
Figure 11 Subwindow Status of measurement

Press the "Stop Measurement" button to stop data recording.

Press the "Graphic Snapshot" button to plot the measurements. The freeware "Gnuplot" script is used for this purpose. See Figure 12. It is used for the first evaluation of correct settings and proper progression of the measurement. Gnuplot offers only snapshots of current data sets. The graphic will not be updated automatically. Press the "Graphic Snapshot" again for updating.
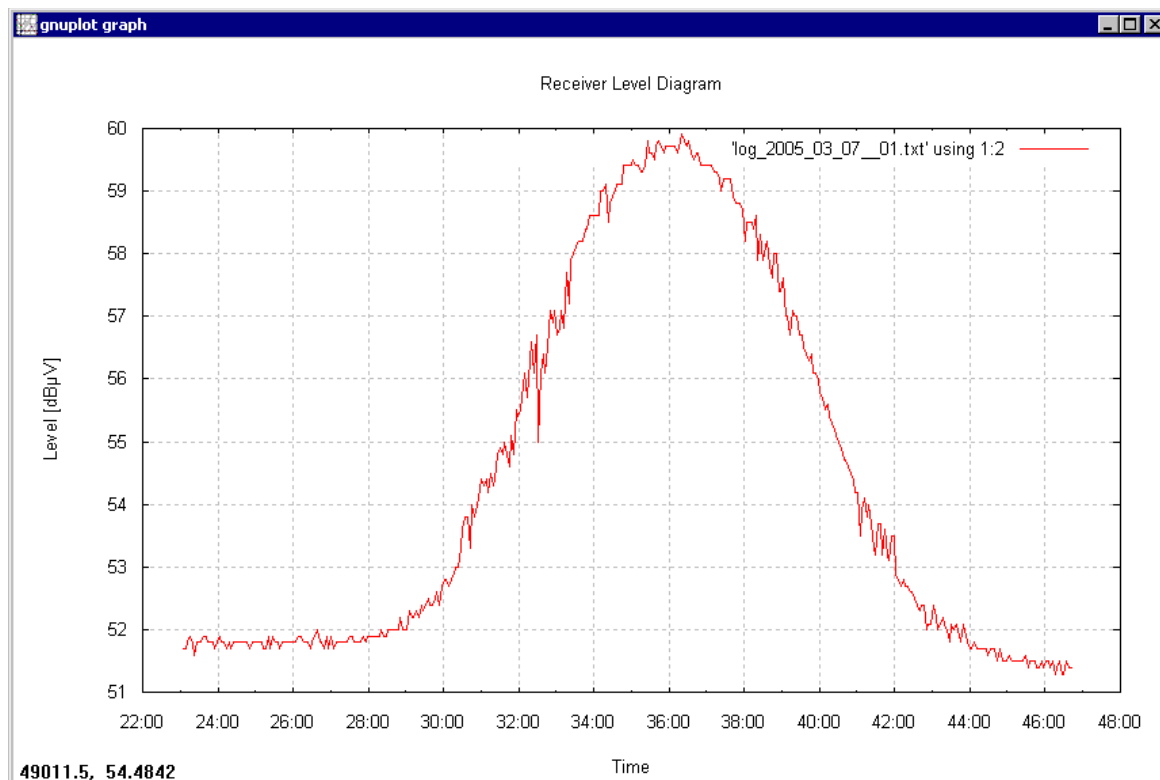
Figure 12 Rapid graphical evaluation with Gnuplot

Ending the operations:
Click on the "Close" button to terminate the connection between the RadioAstro software and the measurement receiver.

2.3.2 How to work with "Le Cartes du Ciel"

"Le Cartes du Ciel" is a very useful freeware program for calculating the coordinates of almost every commonly-referenced astronomical object. It may be downloaded from http://astrosurf.com/astropc/cartes/index.html for free, and is available in several languages (English, French, German, Greek, and Portuguese). It gives a map of astronomical objects according to date, time and observer location. The position of most celestial objects may be determined based on date, time and location with respect to the both relevant coordinate systems (AZ-EL and equatorial coordinates). Additionally, the software provides excellent animation of star movements with user-controlled speed and sector adjustment.

Operation example:

1. Start the program "Le Cartes du Ciel"
2. Press the "Observatory" button and specify your exact observatory location in the dialogue box (Figure 13):
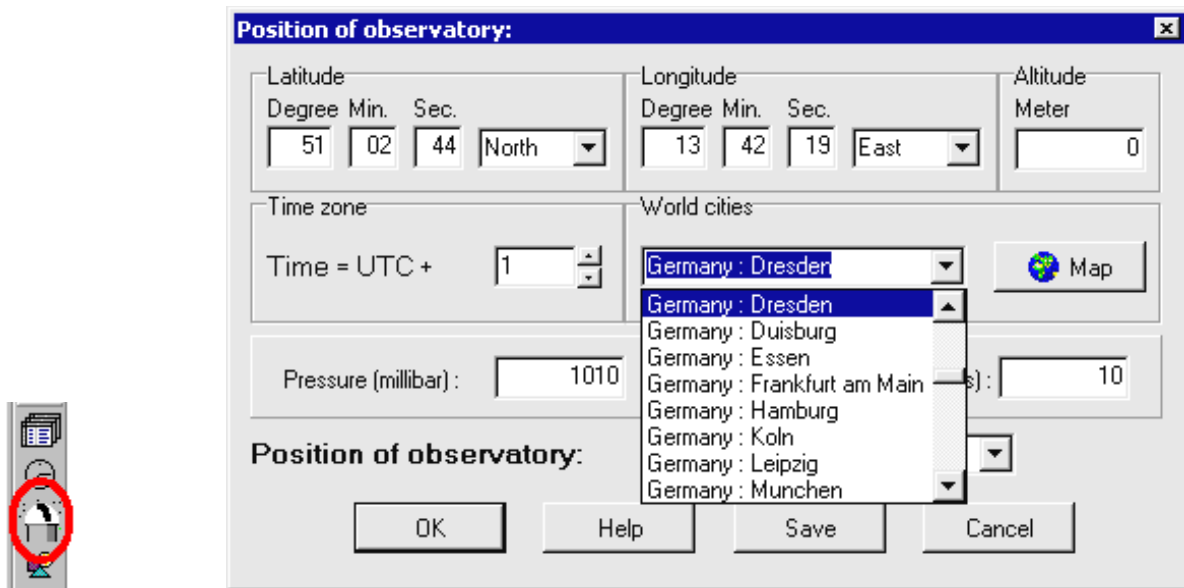
Figure 13 Selecting Position of observatory

3. Press the "Date/Time" button and specify date/time for which you would like to know the position of astronomical object (Figure 14). Check that the local time is calculated with the correct offset according to UTC. Don't forget the daylight savings time in summer.
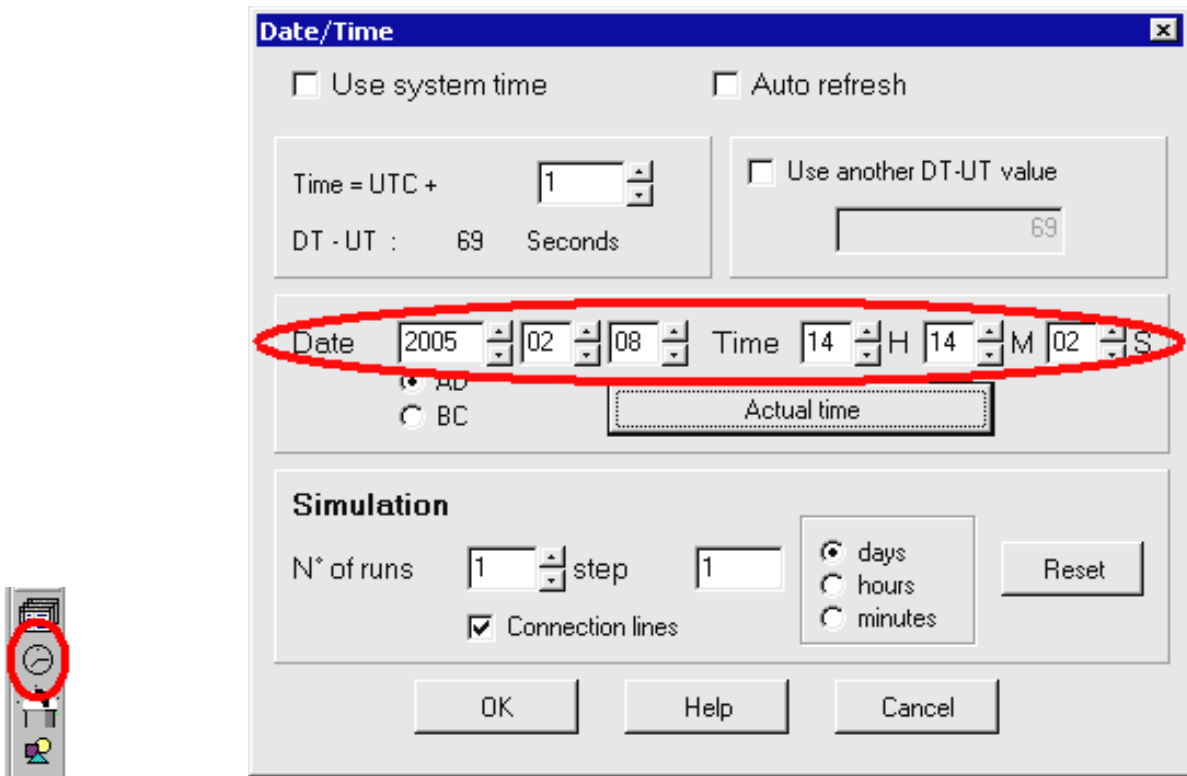
Figure 14 Setting Date and Time

4. Search for your astronomical object in the map (Figure 15). Via menu "Lines" ➔ "Equatorial grids" or "Azimuthal grids", you can switch on your preferred grid lines. With "Move" toolbar buttons you can choose the sky section to be displayed.

Figure 15 Specifying grid and sky section

5. Point on your desired astronomical object (the Moon in this example) and note the Az-El coordinates in the status bar. Click on the object to determine the equatorial coordinates (Figure 16).
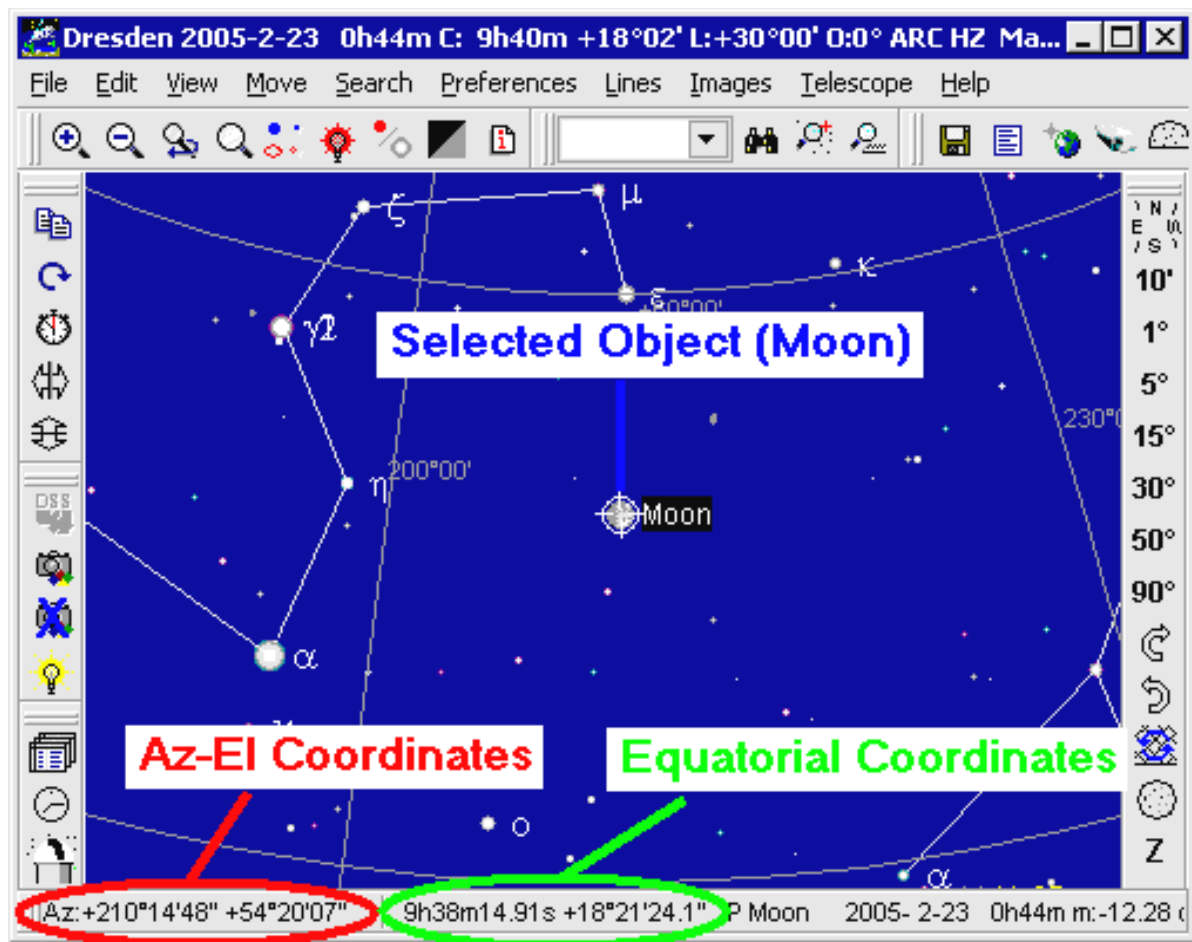
Figure 16 Reading out AZ/EL coordinates

6. Change the date/time to get tracking data of the astronomical object as described in 3.

7. You can see an animation of movement by pressing the button "Animation" and the right arrow button in the dialog (Figure 17). The animation speed may be adjusted in the dialogue box.
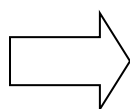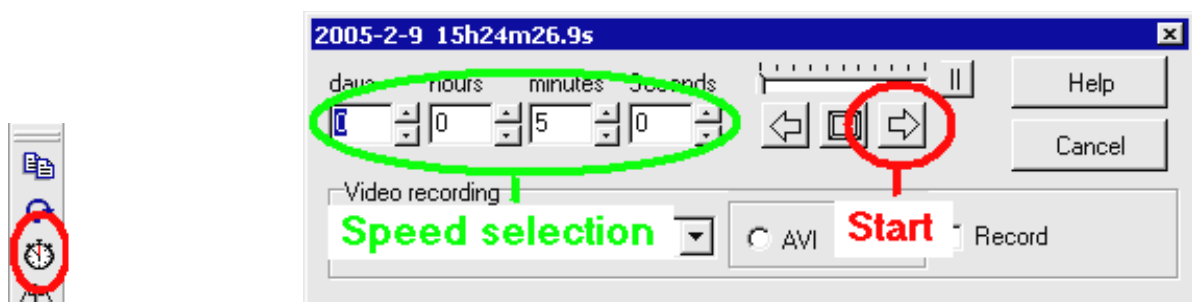
Figure 17 Animation of star movement

"Le Cartes du Ciel" contains an online help system. Press the "Help" button in the corresponding user dialog or choose the "Help" menu in the main dialog. You will find further documentation on the "Le Cartes du Ciel" homepage. See http://www.stargazing.net/astropc/doc/eindex.html .

2.3.3 Postprocessing and visualisation of measurement results

The postprocessing and graphical visualisation can be performed using Microsoft Excel. Once a measurement has been completed, import the measurement data file (e.g. "log.txt") directly into Excel using the File ➔ Open (File Type: Textfile) function of Excel.
Skip the first two rows which contain parameter information, and start instead with the first measurement value (Figure 18). If needed, more complex postprocessing may be performed with the Visual Basic scripting inside Excel.

Remark: For the german version of Microsoft Excel you must convert the decimal points "." into "," for proper procession of numbers (Menu "Bearbeiten" ➔ "Ersetzen").
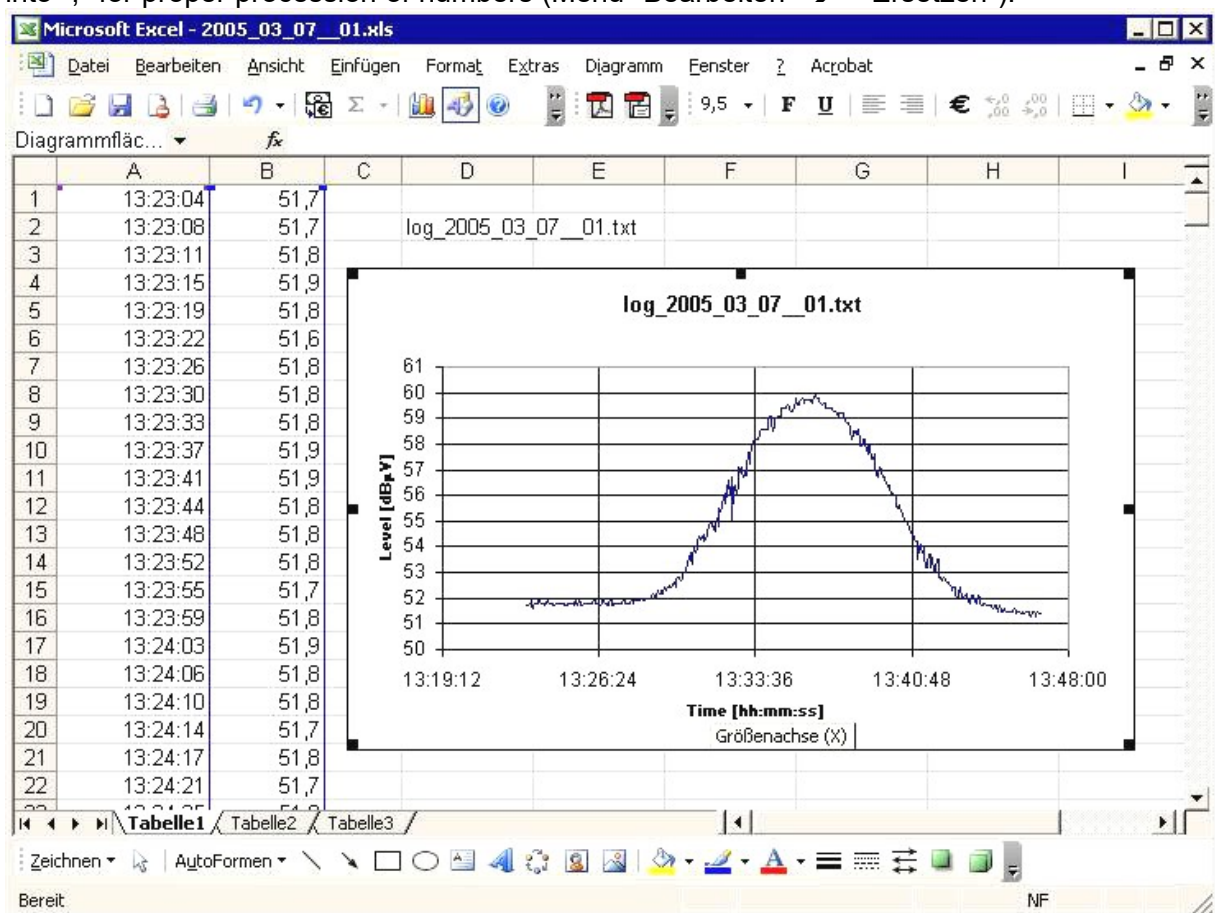
Figure 18 Postprocessing and visualization with Microsoft Excel

Measurement data access from remote PCs via Ethernet/ LANs:
In order to access the measurement data on a local PC from a remote PC, connect both PCs via Ethernet (Point to Point or Local Area Network).
Share the hard disk and folder with the data file on the local PC (Windows Explorer as Administrator ➔ right mouse button ➔ Share).
The remote PC is then able to access the containing files via file system, e.g. by means of Windows Explorer.

3   Example measurements

Sample observations are described step by step in this section. You will learn to observe a Sun transit at a fixed antenna position and how to prepare and execute a Sun tracking.

3.1   Sun measurement

Task:
The radiation flux of the quiet Sun shall be measured for a specified frequency and polarisation for a fixed dish position.

Precondition:
- Calibrated positioning system (see Assembly Manual for details)

Preparation:
- Check all connections between outdoor unit (LNB, Rotator) and indoor unit (Receiver, Rotator Controller, Computer Controller, PC)
- Switch on all devices in the correct sequence

Determine the AZ and EL parameters of the Sun:
- Start "Le Cartes du Ciel" and specify the following parameter:
  - Position of observatory: "Dresden"
  - Date: 7. March 2005
  - Time: UTC + 1h

- Read out the AZ and EL parameters of the Sun, corresponding to a observation time (local time, e.g. UTC + 1h):
  - Take the sky section "Show all sky" first to search for the Sun. Centre the Sun by clicking on the right hand mouse button. Assign "Field width: 15°".
  - Point on the Sun. Read out the AZ and EL values on the status bar below
  - Change the time to the next value listed, and repeat the above actions
  - Result should be as shown in Table 2 (for that location and time):

Time [hh:mm]		AZ Sun [°]	EL Sun [°]
13:00		193	33
13:15		197,2	32,2
13:30		201,4	31,4
13:45		205,7	30,4
14:00		210	29,4

Table 2: Azimuth and Elevation of Sun

Start operation with the RadioAstro software:
- Start the RadioAstro software

- Configure the Measurement (button "Configuration") as follows:
  - Frequency: 12500 MHz
  - Band: High Band
  - Polarization: Horizontal
- Click on the "Open" button in the Measurement subwindow to open the connection to the receiver
- Click on the "Start Measurement" button to start the measurement
  - Check on the receiver LCD display that the receiver is configured correctly
 - Check if the counter in the Status subwindow is counting (this means that measurement points will be received)
- Click on the "Stop Measurement" button to stop the measurement.
- Switch on the control tone which represents the current level:
  - Press "F4" (Level AC) on the receiver
  - Press "F5" (Teletext) on the receiver
  - Adjust Volume control to obtain an audible signal tone
- Press "Open" in the Positioner subwindow to open a connection to the Positioner
- Check that the current position is displayed in the "Status" subwindow (this means that connection is okay, otherwise the text fields are empty)
- Select "fast" speed at the speed control switch on the top hat rail
- Check if the Rotators move according to the arrow keys that are pressed

Searching the AZ/EL position for maximum radiation level:
- The measurement should be stopped, and the control tone should be active
- Write the required Azimuth and Elevation values into the textfield of the Positioner subwindow. Press the "Go to Position" button
  - AZ= 197, EL= 32 at 13:15h
  - Wait until the new position is reached
- Select "slow" speed at the speed control switch on the top hat rail
- Search the position of the exact maximum receiver level by means of tone control and arrow keys in Positioner subwindow
  - the higher the control tone, the higher the receiver level
  - the numeric level value will be displayed in the LCD display of the receiver

Exexcuting the measurement:
- Starting from the position with maximum receiver level, move the dish about 4° clockwise (west direction) to measure also the increase of the radiation level
  - This AZ movement will take about 5s in slow speed mode
  - Check if the signal strength is getting lower, as expected
- Click on the "Start Measurement" button to start the measurement
- Check the measurement progress from time to time using the plotting function (button "Graphic Snapshot") as shown in Figure 19.
  - You may use the both sliders for marking special points (e.g. start value and maximum value so far)
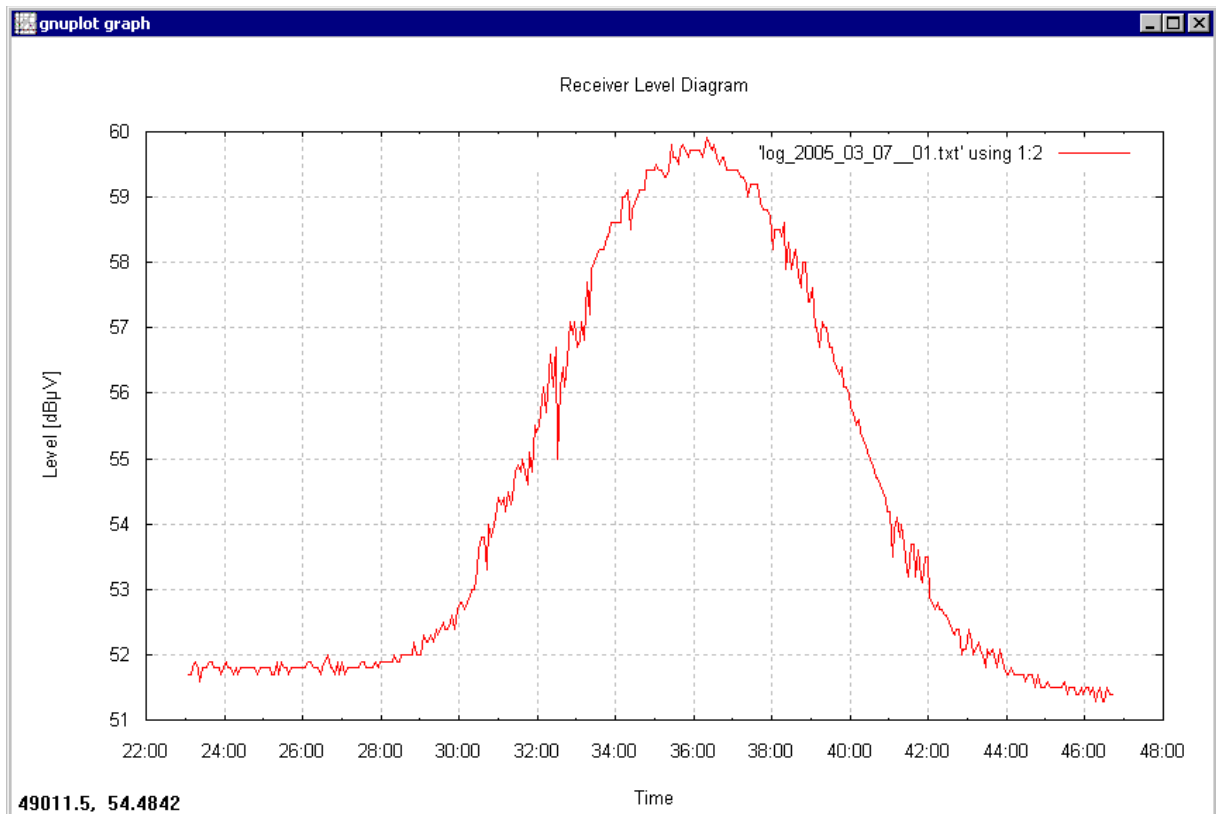
Figure 19 Instant graphical progress view with Gnuplot

Ending the measurement:
- Press the "Stop Measurement" button to stop the measurement
- Deactivate the whole system if no further measurements are planned
    - Press the "Close" button to close connections to the Positioner and receiver
    - Switch off the receiver, Motor Controller and PC Controller
    - Exit the RadioAstro software

Evaluation of results with Microsoft Excel:
- Start Microsoft Excel
- Open measurement datafile with Menu: File ➔ Open (Filter: Text file) ➔ "log.txt"
  ➔ Text Conversion Assistant is started
- Take "Constant Width" and start import with line 3
- Select spaces for separators, and import the data
- Now the time stamps are in the first column, the receiver levels in the second column
- Convert the data type of first column (A) into time format:
    - Selecting column (click on "A" in header)
    - Right mouse click ➔ format ➔ numbers ➔ time
- Create an XY graph:
    - Select both columns (click on "A", Ctrl + click on "B")
    - Press Diagram Assistant toolbar button and choose XY diagram
    - Add labels and ammend the layout via the property settings (Figure 20)
    - Save results: File ➔ Save As ➔ log.xls (Excel format)
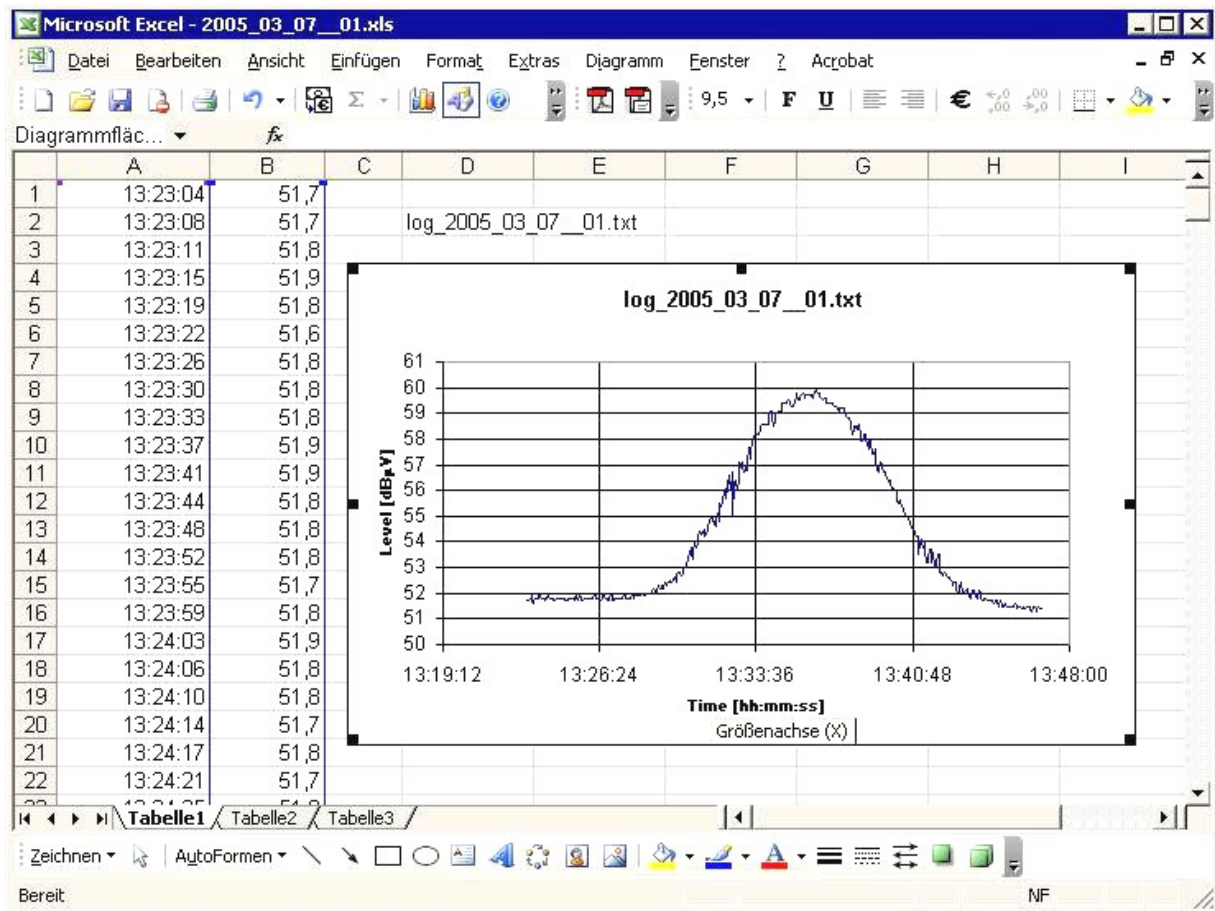
Figure 20 Postprocessing and visualization with Microsoft Excel

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3.2 Automatic Sun tracking

Task:
The radiation of the quiet Sun shall be measured for one hour. A specified frequency, polarization and a tracked dish shall be used. The tracking speed has to be calibrated in advance by means of known satellite positions.

Precondition:
- Calibrated positioning system (see Assembly Manual for details)

Preparation:
- Check all connections between outdoor unit (LNB, Rotator) and indoor unit (Receiver, Rotator Controller, Computer Controller, PC)
- Switch on all devices in the required sequence

Getting AZ and EL parameters of the Sun:
- Starting "Le Cartes du Ciel" and specify the following parameters:
  - o Position of observatory: "Dresden"
  - o Date: 12. Mai 2005
  - o Time: UTC + 2h

- Read out the AZ and EL parameters of the Sun, corresponding to local time (e.g. UTC + 2h):
  - o Take the sky section "Show all sky" first to search for the Sun. Centre the Sun by clicking on the right hand mouse button. Assign "Field width: 15°".
  - o Point on the Sun and read out the measurement values on the status bar below
  - o Change the time to the next value and repeat the actions
  - o Result should be as in Table 3 (for that location and time):

Time [hh:mm]		AZ Sun [°]	EL Sun [°]
13:00		179,2	57,12
14:00		204,5	55,11

Table 3: Satellite dish parameters

Determining the parameters of geostationary satellites for tracking speed calibration:

See Table 4 for the location of the Astra and Telecom 2D satellites.

Parameter	1. Satellite (at start position)	2. Satellite (at end position)
Name	Astra 19.2° East	Telecom 2D
AZ	173,02°	207,13°
EL	31,32°	28,07°
Frequency	11500 MHz	11500 MHz
Band	Low	Low
Polarization	Horizontal	Horizontal

Table 4: Location of the Astra and Telecom 2D satellites.

- Remark: these AZ and EL values of satellites are valid for Dresden only. The AZ and EL values applicable for your own location are listed in tables available at local Sat-TV dealers. On the Internet, see:

  www.ses-astra.com   Media Room / Publications / Azimuth & Elevation
                                     Seite Deutschland : Broschüren / Antenneninstallation
  www.technisat.de   Sat-Infos / AZ/EL-Werte for Germany and Europe

- Frequency, Band and Polarization settings should be the same for both satellites (transponders with same parameters on both satellites)

Starting operation with RadioAstro software:
- Start the RadioAstro software
- Configure the Measurement (button "Configuration") as follows:
  - Frequency: 11500 MHz
  - Band: Low Band
  - Polarization: Horizontal
- Click on the "Open" button in the Measurement subwindow to open the connection to the receiver
- Click on the "Start Measurement" button to start the measurement
  - Check on receiver LCD display if receiver is configured correctly
  - Check if the counter in the Status subwindow is counting (means that measurement points will be received)
- Click on the "Stop Measurement" button to stop the measurement.
- Switch on control tone which represents current level (measurement must be stopped for that function):
  - Press "F4" (Level AC) on receiver
  - Press "F5" (Teletext) on receiver
  - Adjust the Volume control to get a proper audio signal tone
- Press "Open" in the Positioner subwindow to open a connection to the Positioner
- Check if the current position is displayed in the "Status" subwindow (this means that the connection is okay, otherwise the text fields are empty)
- Select "fast" speed at speed control switch on the top hat rail
- Check if the Rotators move according to the arrow keys that are pressed

3.2.1 Calibration of tracking speed with known satellite positions

Search the AZ/EL position for maximum Astra 19.2 E signal level:
- Measurement should be stopped, control tone should be active
- Write expected Azimuth and Elevation values into text field of Positioner subwindow and press the "Go to Position" button
  - AZ= 173, EL= 31
  - Wait until the new position is reached
- Select "slow" speed at the speed control switch on the top hat rail
- Search the position of the exact maximum receiver level by means of tone control and arrow keys in Positioner subwindow
  - the higher the control tone, the higher the receiver level
  - the numeric level value will be displayed in LCD display of the receiver

Slow speed AZ movement from start position to end position:

- Set speed reduction value 30 for clockwise time controlled rotation (Figure 21).
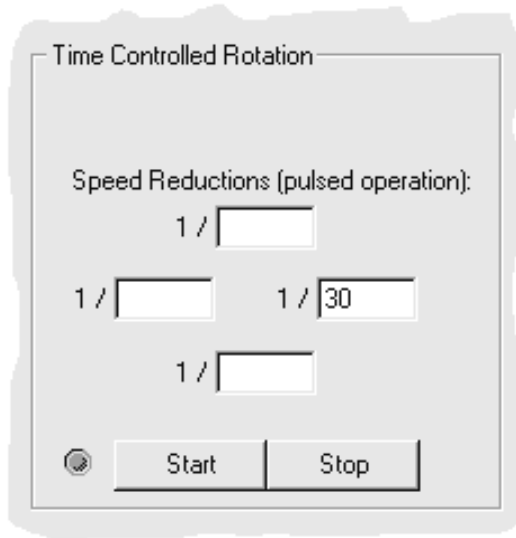
Figure 21 Set slow speed AZ movement with speed reduction value 30

- Start the measurement (button "Start Measurement")
- Check the progress from time to time with the plot function (button "Graphic Snapshot")
  - You may use both the sliders to mark special points (e.g. start value and maximum value so far)
- Stop the measurement if the peaks from the two satellites can be seen clearly, as in Figure 22:
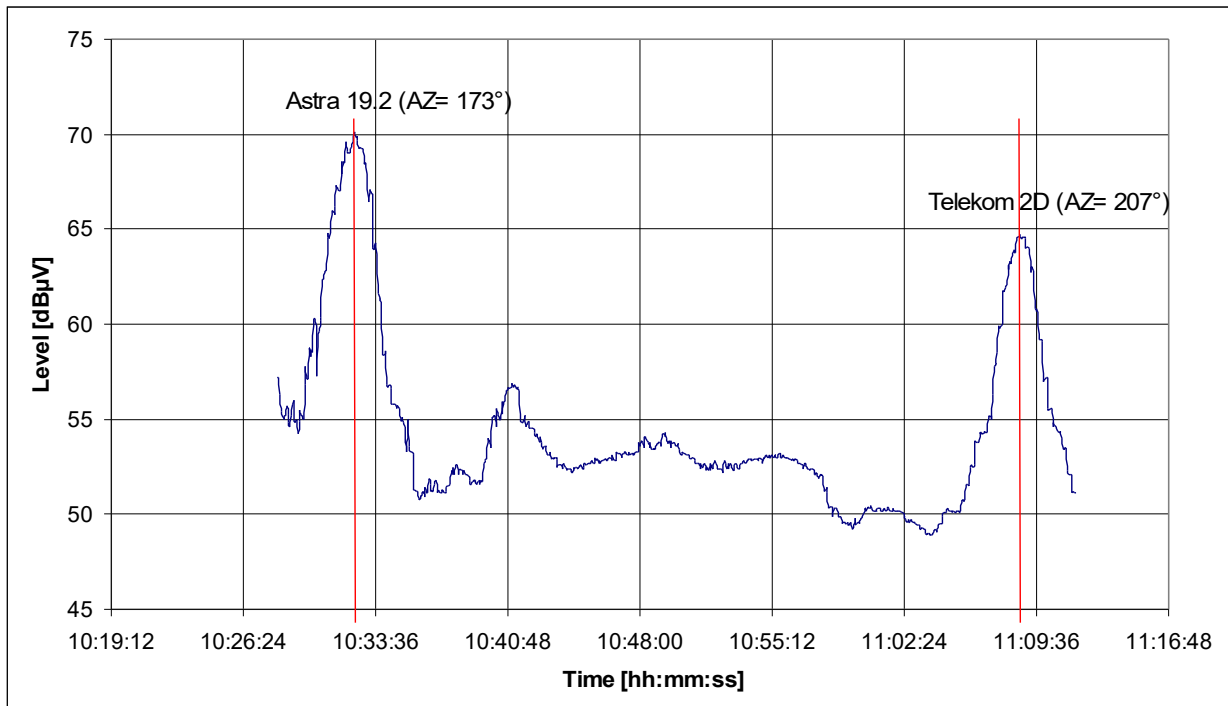
Figure 22 Receiver level peaks from known satellites

Calculation of the calibration data for AZ direction:

First we calculate the speed of the dish movement:

$$v_{dishAZ} = \frac{207.13° - 173.02°}{36.333\,min} = 0.9388°/min \qquad (1)$$

From:

$$v_{red} = \frac{1}{s_{red}} v_{orig} \qquad (2)$$

v_{orig} Original rotation speed direction

s_{red} Speed reduction value (as specified in user interface)

v_{red} Reduced (resulting) rotation speed

Follows:

$$v_{red1} * s_{red1} = v_{red2} * s_{red2}$$

Or for getting the **calibrated** speed reduction value for the sun movement:

$$v_{dishAZ} * s_{dishAZ} = v_{sunAZ} * s_{sunAZ} \qquad (3)$$

s_{dishAZ} Speed reduction value for satellite measurement

v_{dishAZ} Reduced rotation speed for satellite measurement

s_{sunAZ} Speed reduction value for sun tracking

v_{sunAZ} AZ speed of sun

From table above we may calculate the speed of the sun. It is that speed we want to match exactly with our dish movement:

$$v_{sunAZ} = \frac{204.5° - 179.2°}{60\,min} = 0.4217°/min \qquad (4)$$

Finally we can calculate the calibrated speed reduction value for AZ movement from (1), (3) and (4):

$$s_{sunAZ} = \frac{0.9388°/min * 30}{0.4217°/min} \approx 67 \qquad (5)$$

Calculation of the speed reduction value for EL direction:

The speed reduction value for EL direction is not very critical because of the small angular change.

$$S_{red} = \frac{v_{orig}}{v_{red}} \tag{2}$$

From the table above, we may calculate the EL speed of the Sun. It is that speed which we want to match exactly with our dish movement:

$$v_{redEL} = v_{sunEL} = \frac{57.12° - 55.11°}{60\,\text{min}} = 0.0.0335°/\text{min} \tag{6}$$

$$v_{origEL} = 12°/\text{min} \tag{7}$$

From (2), (6) and (7) follows:

$$S_{sunEL} = \frac{12°/\text{min}}{0.0335°/\text{min}} \approx 358 \tag{8}$$

This is the speed reduction value for EL movement that should be used for the tracking of the Sun.

3.2.2 Execution of automatic Sun tracking

Search the AZ/EL position for maximum signal level:
- Measurement should be stopped, control tone should be active
- Select "fast" speed at the speed control switch on the top hat rail
- Write expected Azimuth and Elevation values into text field of Positioner subwindow and press the "Go to Position" button
    - AZ= 179, EL= 57 at 13:00h
    - Wait until the new position is reached
- Select "slow" speed at speed control switch on the top hat rail
- Search the position of the exact maximum receiver level by means of tone control and arrow keys in Positioner subwindow
    - the higher the control tone, the higher the receiver level
    - the numeric level value will be displayed in LCD display of the receiver

Executing the measurement:
- Click on the "Start Measurement" button to start the measurement
- Set speed reduction value to 67 (see equation (5)) for clockwise time controlled rotation (AZ) as shown in Figure 23
- Set speed reduction value to 358 (see equation (8)) for downside time controlled rotation (EL)

- Start the time controlled rotation (button "Start")
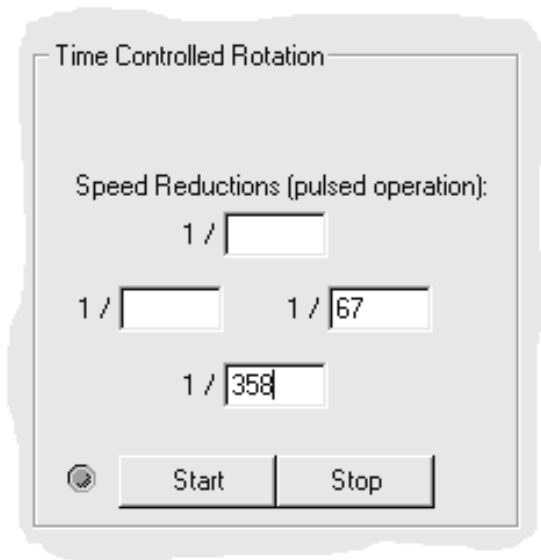
Figure 23 Set slow speed movement with speed reduction values for Sun tracking

- Check the progress from time to time with the plotting function (button "Graphic Snapshot")
- You may use the both sliders for marking special points (e.g. start value and maxmum value so far)

Ending the measurement:
- Stop the measurement (button "Stop Measurement" and "Stop" in the Positioner subwindow) after one hour
- Manually search the AZ/EL position for maximum signal level to confirm that the tracking was successful (See Figure 24.)
- Deactivate the whole system if no further measurements are planned
    - Close connections to Positioner and receiver (buttons "Close")
    - Switch off the receiver, Motor Controller and PC Controller
    - Exit the RadioAstro software
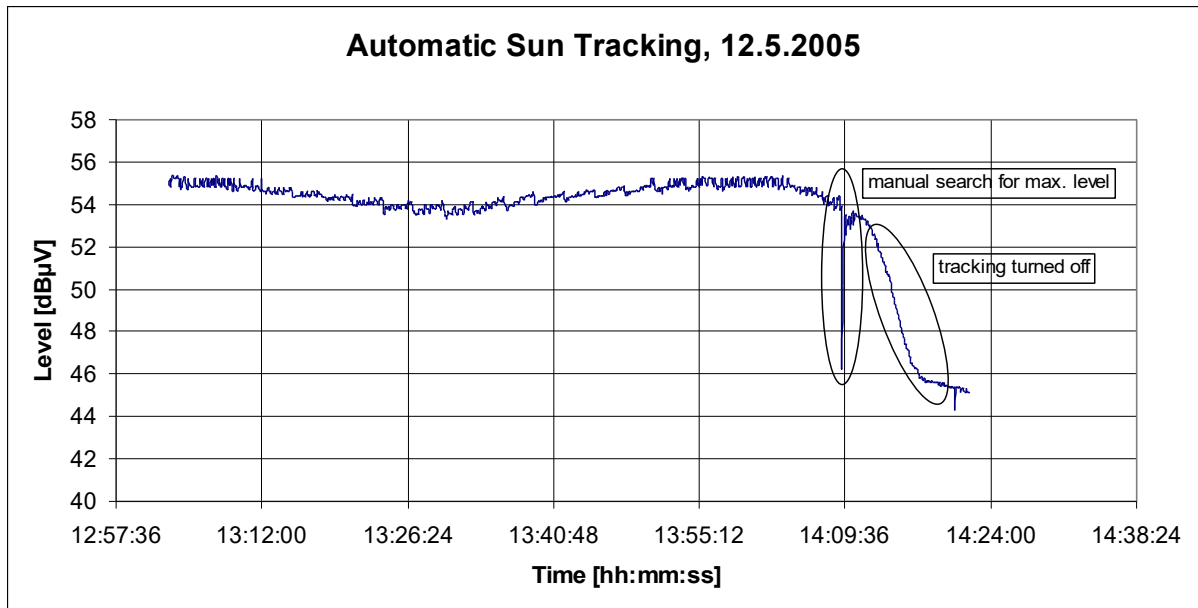
Figure 24 Result for automatic Sun tracking

Evaluation of results with Microsoft Excel:
- Start Microsoft Excel
- Open the measurement datafile with Menu: File ➔ Open (Filter: Textfile) ➔ "log.txt"
  ➔ Text Conversion Assistant is started
- Take "Constant Width" and start import at line 3
- Select spaces for separators and import the data
- Now the time stamps are in the first column, the receiver levels in the second column
- Convert the data type of first column (A) into time format:
  o Select column (click on "A" in header)
  o Right-hand mouse click ➔ Format ➔ Numbers ➔ Time
- Make an XY graph:
  o Select both columns (click on "A", Ctrl + click on "B")
  o Press Diagram Assistant toolbar button and choose XY diagram
  o Improve the layout and labels via the property settings
  o Save results: File ➔ Save As ➔ log.xls (Excel format)

Remark: For the german version of Microsoft Excel you must convert the decimal points "."
into "," for proper procession of numbers (Menu "Bearbeiten" ➔ "Ersetzen").

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Extending the software with your own programming
The following suggested extension should be made only by experienced students. Note that the underlying libraries (RadioAstroPos und RadioAstrMeas) remain unchanged for these extensions.

3.3   Programming with Visual C++

Open the software project "RadioAstro.dsw" within the Microsoft Developer Studio (Visual C++ 6.0 or newer). Explore the project (class view, resource view and file view) and insert your extensions as demonstrated by already implemented functions.

Some main parts are explained in Table 5:

Name	Best view or tool for exploration	Remarks
CRadioAstroView	Class View	Implementation of all user interface related functions and members. All manual programmed sections (not provided from the framework) are commented with **//---**
IDD_RADIOASTRO_ FORM, IDD_DIALOG_POS_ CONFIG, ..	ResourceView	Graphical design of main window and subwindows. Use "Controls" toolbox and "ClassWizzard" to add new elements
String Table	ResourceView	Contains all text strings for application
RadioAstroMeas.h	File View	API with description for the RadioAstroMeas-Library (DLL)
RadioAstroPos.h	File View	API with description for the RadioAstroPos-Library (DLL)

Table 5: Visual C++ Application

3.4   Programming with Visual Basic 6.0

Open the software project "RadioAstro.vbp" within the Visual Basic 6.0 IDE (Integrated Development Environment). Use the integrated Project Explorer to explore the whole software project. It is started via menu View ➔ Project Explorer.

Some main parts are explained in Table 6:

Name	Best view or tool for exploration	Remarks
MainDialog, About Dialog, MeasConfigDialog, PosCalibrationDialog, PosConfigDialog	Project View ➔ Forms	Main window and subwindow designs. Use View ➔ Toolbox to add new elements Doubleclick on elements to add functionality and see source code of program. Rightclick ➔ Properties to view elements properties
RadioAstroMeas	Project View ➔ Modules	API with description for the RadioAstroMeas-Library (DLL)
RadioAstroPos	Project View ➔ Modules	API with description for the RadioAstroPos-Library (DLL)

Table 6: Visual Basic 6.0 Application

3.5 Migration from Visual Basic 6 to Visual Basic .net 2003

The migration from Visual Basic 6 software project to Visual Basic .net 2003 version is described in this section and is of interest for advanced programmers only. Unfortunately, more than ever before has changed with the current .net version. The RadioAstro software is implemented intentionally with the older Visual Basic 6.0 version for two reasons. Firstly, to support developers who don't have the newest development software. It is possible to migrate from Visual Basic 6 version to .net version with some difficulties, but not vice versa. A Visual Basic .net project is not downwards compatible. Secondly, the Visual Basic 6 developer's environment has much easier handling for beginners than the complex Visual Basic .net environment.

The following steps must be executed for the migration of RadioAstro software from Visual Basic 6.0 to Visual Basic .net 2003:

- Make a backup of the whole project for safety reasons
- Start Microsoft Visual Studio .NET 2003
- Open Visual Basic project: RadioAstro.vbp
- The Update Assistant will be started:
    - Choose directory for the new project (do not take a subdirectory)
    - Start the conversion process (this takes some minutes)
- Manually copy the following data from old project into the new "bin" directory:
    - complete "res" directory
    - RadioAstroMeas.dll
    - RadioAstroPos.dll
    - script_template.plt
    - wgnuplot.exe
    - wgnuplot.hlp
    - wgnuplot.mnu
- Check all graphical elements (windows, menus, buttons, ..) for correctly executed conversions (e.g. size and position modified text boxes)
- In some cases, the main window does not get a windows frame at all. Change the property of the main dialogue: FormBorderStyle: change from "None" to "Fixed Dialog"

3.6   First concepts for software extensions

Continuously updated graphic display:
Gnuplot offers only snapshots of current data sets. Use the language specific graphics programming to create a continuously updated graphic display.

Remote PC access and controlling:
One advisable solution is to program a socket communication (client and server implementation) on both sides and an additional user application on remote side. With an established socket connection, local and remote PC can communicate via TCP/IP. Special commands and messages have to be implemented to provide every possible controlling and observing function.

4   Troubleshooting

The following hints are aimed to support the user in case of problems, related to the categories

A - Rotator Unit
B - Receiver
C - Measurement
D - RadioAstro Software

A - Rotator Unit

#	Problem	Cause	Recommended Action / Remark
1	Antenna is shaking in AZ direction in windy conditions	Slack of rotator gears	Install rubber band at the AZ rotator as described in the Assembly Manual

B - Receiver

#	Problem	Cause	Recommended Action / Remark
1	Dark LCD display (poor readability)	Background light isn't switched on	Press "Mode" key, then "1" followed by "11" for switching on the background light

C - Measurement

#	Problem	Cause	Recommended Action / Remark
1	Not able to find the astronomical object at expected position (maximum level searching)	Wrong time setting used in "Le Cartes du Ciel"	Check for correct setting in Date/Time dialog. Daylight saving time has to be regarded.
		Positioning system (rotator) is not calibrated	Calibrate position system according to Assembly Manual.
2	Big level jumps during measurement	Windy weather conditions and not stabilisation with rubber band	Stabilisation with rubber band as described in "Assembly Manual"
		Warm-up of receiver not completed	Wait until end of warm-up: at least 10 minutes

D – RadioAstro Software

#	Problem	Cause	Recommended Action / Remark
1	Error Message: "Could not open COM-port."	The COM intended for use is not available at this PC or is used already from other device	See hardware management of PC (Device Manager ➔ Ports) if desired port is available.

2	Current positions not displayed in Status subwindow after "Open" connection to device	PC Controller is not switched on	Switch on the controller.
		RS232 cable is not connected or wrong type of cable is used	Use a **Modem** cable and Gender Changer on PC Controller for connection **(Note: Nullmodem cable does not work**).
		Wrong COM-port is selected (Configuration Dialog)	Check if COM-port number specified in Configuration Dialog is identical to the COM-port used on the PC
		In some rare cases, the PC Controller learned the wrong Baudrate	Switch the PC controller off and on and try to connect again with "Open".
3	Receiver does not use the specified configuration parameters, or Counter in Status subwindow does not count	RS232 cable is not connected, or wrong type of cable is used	Use a **Nullmodem** cable and Gender Changer on PC Controller for connection (**Modem cable doesn't work!**).
		Wrong COM-port is selected (Configuration Dialog)	Check if COM-port number specified in Configuration Dialog is identical to used COM-port on PC
		RS232 settings of receiver are incorrect	Change the RS232 settings to default values: 9600 Baud, 1 Stop Bit
4	Miscellaneous error messages or running problems	Restrictive security management of windows system	Try to start the software with Administrator privileges and find the restriction source.
5	Starting or running problems with the Visual Basic version of RadioAstro software	Runtime environment of windows system is not suitable in some rare cases	Use the Visual C++ version of RadioAstro software. It works more reliably.

5   References

[1] Kraus, John D.: Radio Astronomy (2nd Edition), Section 9 Fundamentals of Radio Astronomy, Cygnus Quasar Books, 1986

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[3] YAESU: GS-232B Computer Control Interface for Antenna Rotators, Manual, 2004

[4] YAESU: G-5500 Instruction Manual, 1998