R2S

PRIMALUCELAB

RadioUniversePRO

USER MANUAL

Version 1.6.1 - update 22/02/2021

SCIENCE & INNOVATION

MADE IN ITALY

This manual describes the use of RadioUniversePRO software for SPIDER radio telescopes. Before using the software, the user has to read and follow the "Installation and Maintenance manual" of the the radio telescope.

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- **SAFETY RULE**: by using the SPIDER radio telescope, the user understand that no person has to stay close to the radio telescope since the antenna may move and hit the person if too close to it. The user accept PrimaLuceLab SpA can't be held responsible if someone hurts or get injured being too close to the radio telescope. Especially in bad weather conditions no person is authorised to be close to the radio telescope that has to be controlled from the remote control room (where the receiver is located).

- In any case the user is not sure on how to properly use the radio telescope, the user has to contact PrimaLuceLab team (info@radio2space.com or +39/0434/1696106) BEFORE using the radio telescope.

Read this before using RadioUniversePRO software

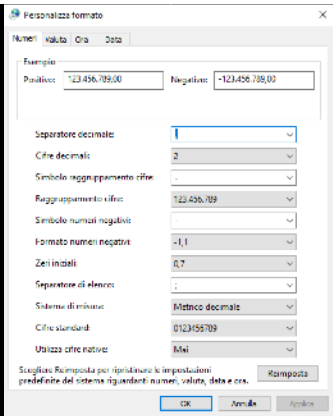
RadioUniversePRO is the software we designed specifically to control SPIDER radio telescopes and acquire radio astronomy data. In order to run RadioUniversePRO, it must be installed on a host computer (not provided with the radio telescope) with the following minimum specifications:

- Operating system: Windows 10 (suggested: 64 bit version)
- Screen resolution: at least 1920 x 1080
- RAM memory: 4 GB (suggested: 8 GB)
- Processor: i3 (suggested: i5 or i7)

In order to install RadioUniversePRO, double click on the setup.exe file included with the installation files and follow the guide on the screen in order to complete the installation.

VERY IMPORTANT

When the installation is completed, please use Windows File Manager to access to the installation directory (usually C:\Program Files\RadioUniversePRO), select RadioUniversePRO.exe file, make a mouse right click and check that, under “Compatibility” tab the “Execute as administrator” option is selected
Check for international settings: go to Control Panel, Region and click on Additional Settings. Here check that the “Decimal symbol” is the , (comma) and that the Digit Grouping Symbol is the . (point). Then click OK to confirm.



When the installation is completed, please use Windows File Manager to access to the installation directory (usually C:\Program Files\RadioUniversePRO), select RadioUniversePRO.exe file, make a mouse right click and check that, under “Compatibility” tab the “Execute as administrator” option is selected

Check for international settings: go to Control Panel, Region and click on Additional Settings. Here check that the “Decimal symbol” is the , (comma) and that the Digit Grouping Symbol is the . (point). Then click OK to confirm. Now you can start RadioUniversePRO software.

Safety notes

- Do not use RadioUniversePRO software without reading and fully following the “Installation and maintenance manuale” of your SPIDER radio telescope.

- RadioUniversePRO software do not allow the radio telescope to point object too close to the horizon, this value is 15 degrees by default. But if you want (and at your risk) you can reduce this value. In order to do this, just exit from RadioUniversePRO software go to RadioUniversePRO installation directory (it should be C:/program files/RadioUniversePRO) and open the file my settings.ini with Windows Notepad. Find the “elevation” value under mount settings (you will see it’s 15) and reduce to 10. Then Save and exit from Note. Now you can start RadioUniversePRO again.

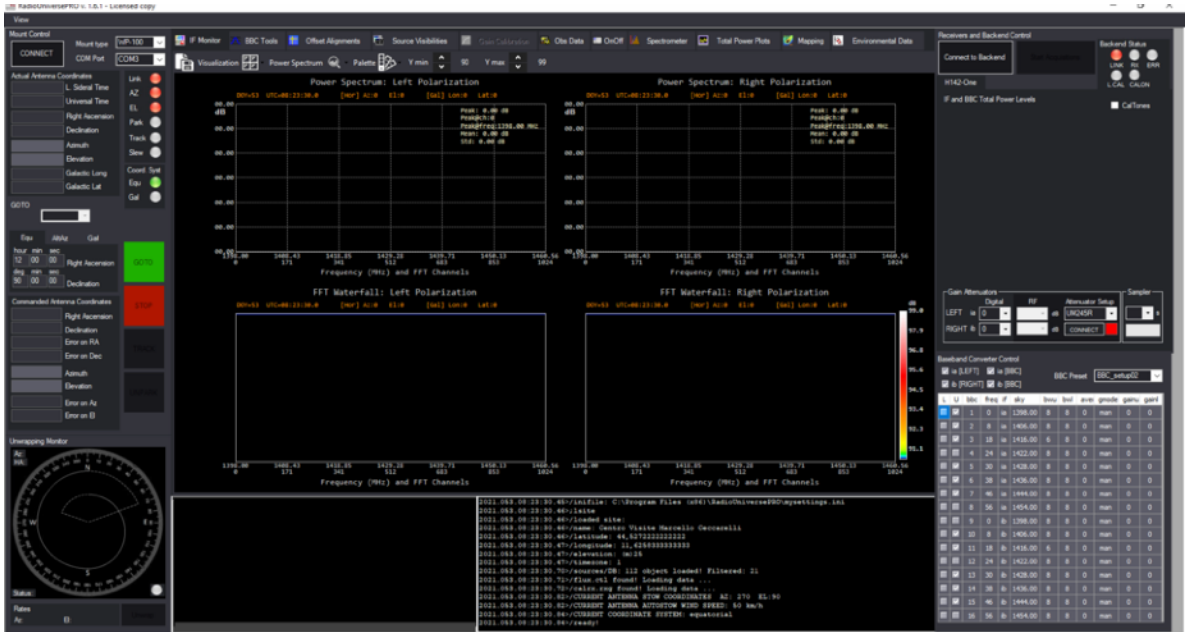
Quick Start guide

In order to properly use the SPIDER radio telescope with the RadioUniversePRO software, please use this quick guide as reference and go to the next paragraphs to know more about the software features:

1) **Turn on the mount and receiver** power by pressing the power button in receiver and mount (mount box installed in the control room if you have SPIDER 300A or 500A, power ON button on the mount head if you have SPIDER 230C).
2) **Start RadioUniversePRO software** installed in your computer (please verify that the "Run as administration" option is selected. In order to do that, please go to RadioUniversePRO installation directory, for example c:/Programs/RadioUniversePRO, make a right-slick on RadioUniversePRO.exe file, select "Compatibility" tab and select "Run as Administration" option).
3) **Connect to the mount** by selecting the proper option in the left column.
4) **Connect to the receiver** by selecting the proper option in the right column.
5) **Verify that the left column correctly shows the actual radio telescope position** under "Actual Antenna position" (if you have SPIDER 300A or 500A, it should show the stow position AZ and EL coordinates that are Azimuth=270 and Elevation=90; if you have SPIDER 230C it should show Azimuth close to 0 and Elevation close to your Latitude if you start from mount HOME position).
6) **Click on UNPARK button** (if you you use the SPIDER 300A or 500A radio telescopes, if you have the SPIDER 230C radio telescope this step is not necessary).
7) **Select Source Visibility tab and make a mouse double click on one of the visible (green coloured) radio sources** to move the radio telescope on the selected radio source.
8) **Look at IF monitor and verify the presence of artificial interferences**. If present, please use the BBC tool instrument.
9) **Perform an automatic alignment of the radio telescope** by using the Offset Alignment tool.
10) **Record your data** by using the proper OnOff, Total Power Plots and Mapping features.
11) When you finish using the radio telescope, **park it in stow position** (Azimuth=270 and Elevation=90).
12) **Disconnect the mount and receiver** in the RadioUniversePRO software.
13) **Turn off the power** from the receiver box and mount.

First use of RadioUniversePRO software

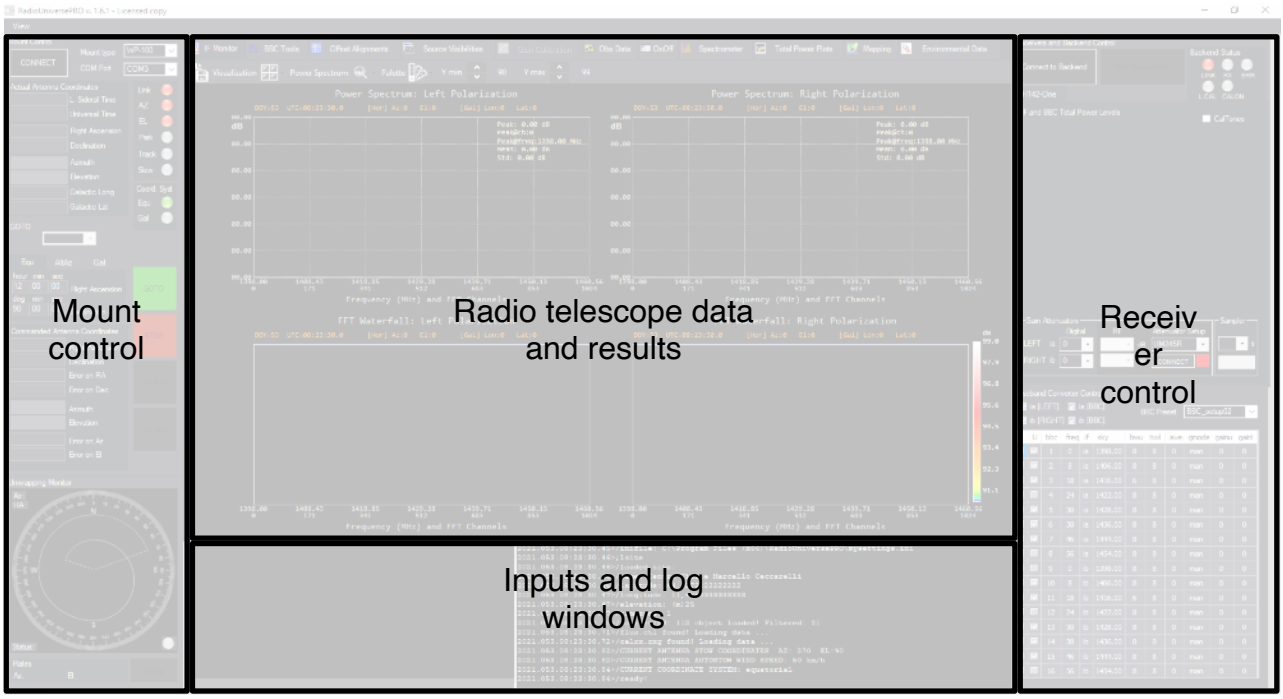
Please double clicking on the RadioUniversePRO icon in your computer desktop, this will open RadioUniversePRO software. RadioUniversePRO software is designed to allow you to have, also in a single monitor view, all the informations and controls of the SPIDER radio telescope.



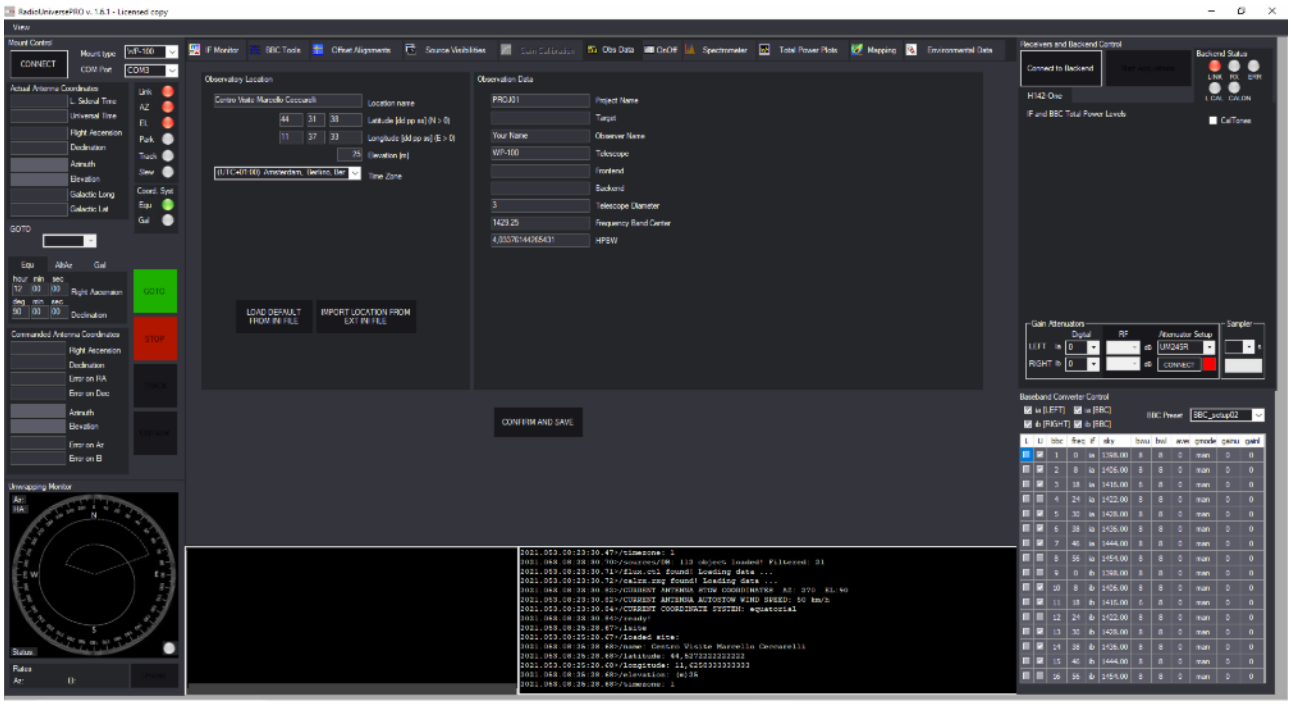
The main window is divided into 4 parts:

- Part 1 (left column): here you find all the data related to the radio telescope mount (both equatorial and altazimuth ones): connection buttons, mount positions, pointed object selection and data, functions buttons, unwrapping monitor (for alt-az mount) and manual movement buttons.
- Part 2 (central area): here you find 10 tabs that give you full access to all the radio telescope features. These will be later described but here you have the tabs list
  - Planetarium (to be added)
  - IF Monitor
  - BBC Tools
  - Offset Alignment
  - Source Visibilities
  - Gain Calibration
  - User Data
  - OnOff
  - Total Power Plots
  - Mapping
- Part 3 (right column): here you find the area related to receivers and data acquisition. Here you can connect to the receiver, have a quick look at BBC Total Power Level (if connected to H142-One receiver), choose receiver settings, activate BBC bands, etc.

- Part 4 (bottom): the bottom part shows the Input Window where you can write manual commands and define your scripts (described later in this manual) and the Log Window there you can see system messages that describe the radio telescope functioning.



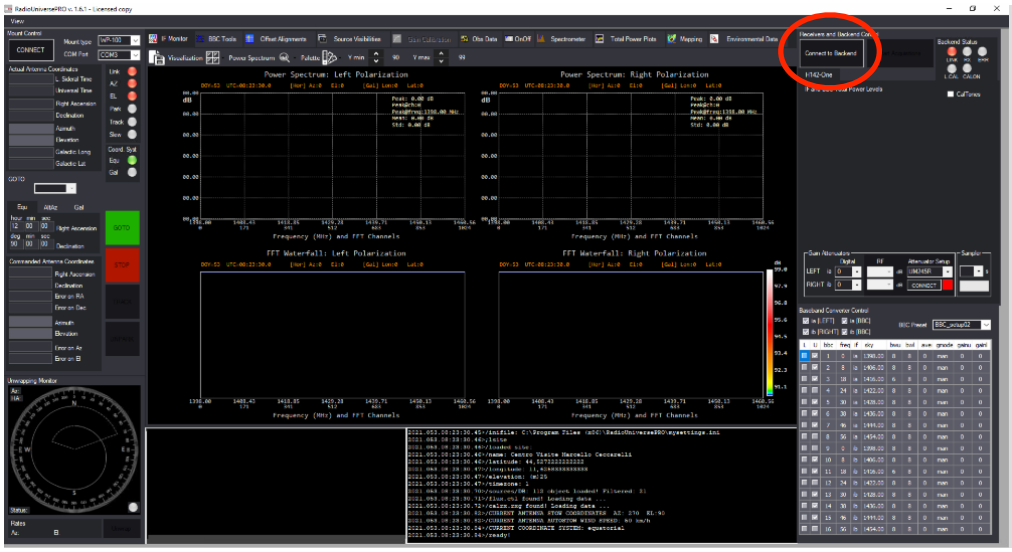
Before using the SPIDER radio telescope, you have to insert your location data in the software. Please click on the “Obs Data” tab, this will open this window:



Please insert your Location name, Latitude and Longitude data (in “degrees, minutes, seconds” format), the elevation and time zone. Press the OK button to save the data on the .ini file and use these data for computations.

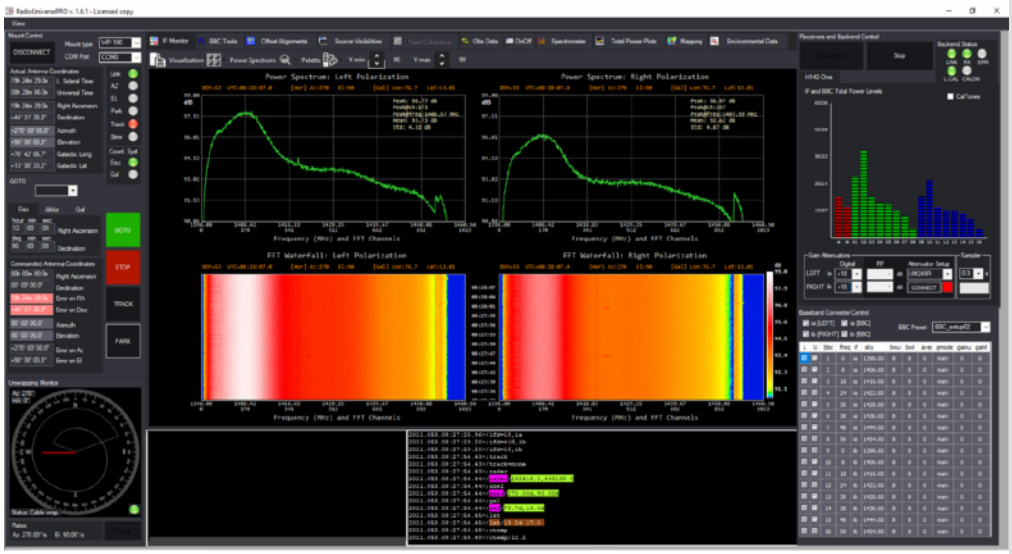
Connect to the radio telescope receiver

Before connecting to RadioUniversePRO software the receiver has to be powered on and connected with the control computer where you have RadioUniversePRO software. In the Receiver control area (on the right column) please press the “Connect to backend” button and, in the Log Window area you will see connection status messages to the receiver. Please remember that, in order to connect to the H142-One receiver, your control computer has to have a static IP number in the 192.168.1.x range (receiver is 192.168.1.101).

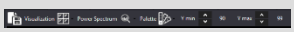


NOTE: based on your country, you may have a power converter to properly power the receiver. For example, for USA there is a unit that converts 110V to the 220V requested by the receiver to work. Please turn on this converter **FIRST**, then you can power the receiver box. When you finish with the SPIDER, please turn off the receiver box and then the converter.

Then select “Start acquisitions” button: the IF monitor will display the data coming from the radio telescope to the receiver in form of a Power Spectrum (upper row) and FFT Waterfall (lower row), both for Left and Right Polarization. Power spectrum is the graphical representation of the electromagnetic power distribution in the operative band, through the RF chain. The spectrum graph shows, for every channel, signal spectral power: that is, the levels are proportional to the square of the input signal of the FFT execution. The power spectrum is then used to calculate the total power use through the integral of the entire bandwidth on the left and right channels. Total power values are reported on the right column graph “IF and BBC Total Power level” with the labels “ia” and “ib” that indicate the values “Intermediate Channel A” and “Intermediate Channel B” (IF left and IF right).



In the upper part of the window you have the controls that allow you to modify the visualisation of the signal. You can change the graph type, show or hide the channels and frequencies on X axis, show the Data info box, and change the minimum and maximum values of the Y axis.



BBC Tool

BBC Tools window allow you to visualise in real time the uncalibrated power spectrum of the input signal in both IF left and right. Often we can find interferences in the IF or, more simply, there may be parts of the spectrum that we don't want to consider during the measurements. For this reason RadioUniversePRO allows you to use a group of digital filters (16+16) fully tunable on the 2 Intermediate Frequencies. Every filter is identified by a BBC (Base Band Converter) label and a number from 01 to 16. Every filter can be set in frequency (starting frequency in base band in the IF), in bandpass (the width of the filter band and that will define it's radiometric sensitivity and the "exposition" to RFIs) and you can choose the IF to whom to associate it. For example the BBC02 can be associated with the IF left or right by using the options in the

lower part of the BBC Tools window. RadioUniversePRO starts with a default configuration that can be fully modified and saved (by clicking the "Saved new setup" button) for the future use.
Every RadioUniversePRO procedure (like creating a radio map, create a total power plot, perform offset alignments on a radio source or the gain calibration) can be performed on a precise BBC setup in order to let you optimise the used bandwidth (by excluding RFIs in band or centering one or more filters on a particular region of the spectrum for the Hydrogen study).

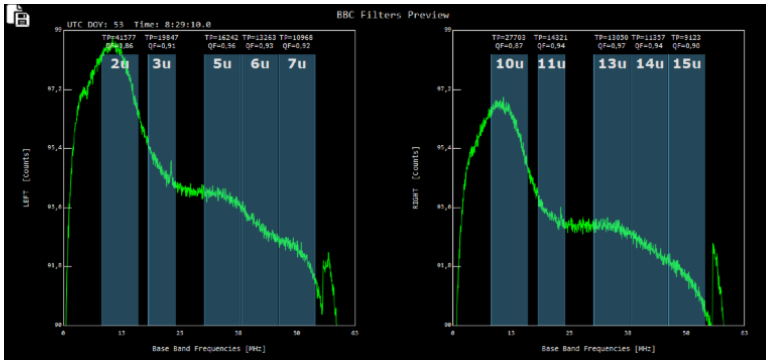
BBC filters are very important to remove unwanted signals from recordings. In order to do so, look at the real time spectrum and search for very narrow signals, if any. These will be most probably artificial interferences (but please not to confuse with the 1420 MHz neutral Hydrogen line!). In order to personalise the BBC setup, please follow this procedure:

1) Activate or deactivate one or more BBC filters (as you can see in the picture above) by selecting the corresponding USB option
2) Every BBC filter can be personalised: you can change "Freq.", "BWL" and "BWU" values for every filter and then press ENTER in the keyboard to apply. You will see the position of the corresponding filter changing just below the spectrum.
3) When you find the BBC setup that best fits your system, click on "Save new setup" button to apply.

NOTE:
Since SPIDER radio telescope antenna has a high directivity, we suggest you to check BBC filters and the absence of artificial signal every time you move the radio telescope to a new object, before capture.

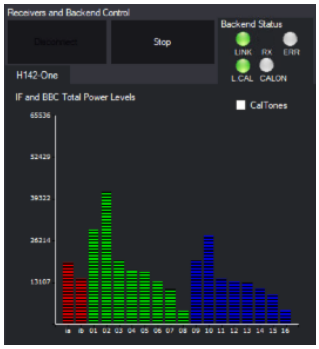
BBC Tool is a very important feature that helps you also to correctly set the gain value for the left (ia) and right (ib) polarisations. In fact, when you record data from the Sun, the radio emission is so strong that you don't need to change the digital gain. But when you want to record data from all the other objects (like Cassiopea A, Cygnus A or Taurus A) you have to increase ia and ib digital gain in order to better match with the system dynamic. In order to do so, we can use the BBC Tool feature and follow this procedure:

1) point the radio telescope to the object you want to record.



2) take a look at the TP levels as reported for every BBC filter.
3) increase the gain for ia (left) and ib (right) polarisation in order to increase the value of TP to around 20000 counts. Please note, avoid too high values because at 65536 counts the BBC filter will be saturated and it will be impossible to record data.

4) You can always have a quick view of the TPI levels by looking to the graph on the right of RadioUniversePRO software, showing both LSB and USB. In red you have the ia and ib TPI levels. In green you have the left polarisation, blue the right one.



NOTE:
Since the IF isn't a flat curve, TPI values for BBC filters may change a lot given a flat digital gain. Please choose a digital gain that offers good and not saturated TPI values for all the BBC filters.

In order to find the best value, after you have the radio telescope tracking the sources move the radio telescope in off position with the command: azeloff=7,7

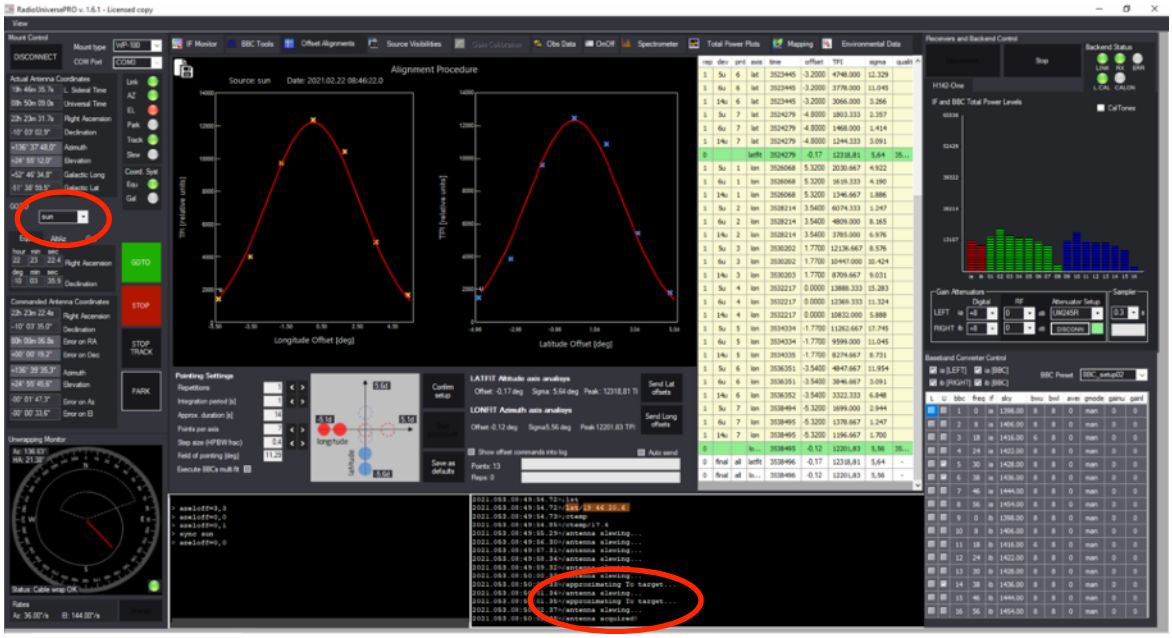
Check for the TPI values and some back to the source (on) position with the command: azeloff=0,0

By comparing TPI counts in ON and OFF positions, you can define the best gain value for your system.

5) Now that you correctly set the digital gain, you can align the radio telescope and capture data.

Offset Alignments

Offset alignments is the instrument that is used to synchronise the radio telescope on the radio sources position on the sky, by reducing the pointing errors on 2 axis of the mount. Before using this tool, you need to point a radio source (by selecting on the “GoTo” window on the left column and clicking on GOTO button or by double-click on one of the listed radio sources in the “Source visibilities” tab). Usually you can use the Sun as a reference radio source since the signal is very strong. On the left “Mount control” column please select Sun as “Target name” and press GOTO button. Wait for the radio telescope to point the Sun, you will see the “Antenna acquired” command in the Log window.



Then, after you selected the proper BBC you want to use, you can design the alignment settings:

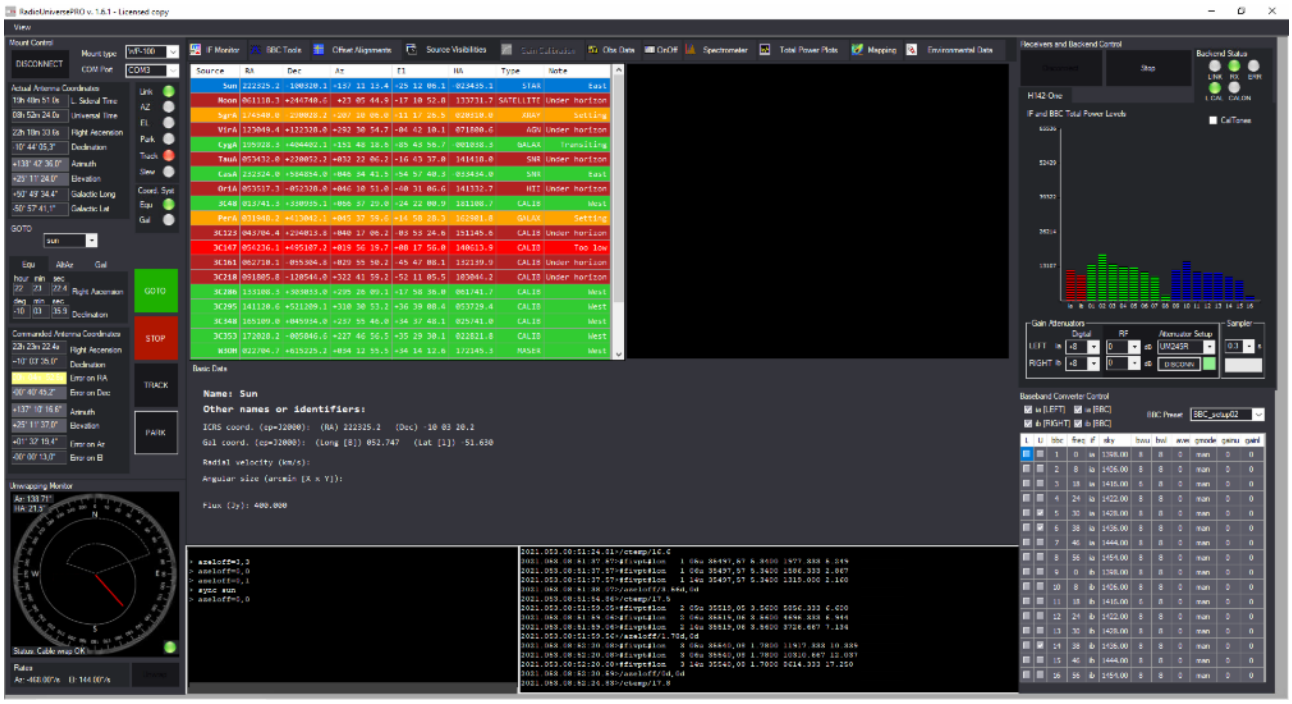
1) Repetitions: how many times the alignment procedure has to be executed (default: 1)
2) Integration period (s): how many seconds the radio telescope has to measure for every point. If you align on the Sun, 1 second is ok. If you align on weaker objects, you can use 5 or 10 seconds for a better S/N.
3) Points per axis: how many points you will have per axis. If you’re not very close to the object, you will set a higher number and the radio telescope will move longer to search for the radio source.
4) Step size (HPWD frac): step size between recorded points. Usually 0.5 is good to start, 0.2-0.3 will be used if you want to make another alignment to refine it.

To start, press the “Confirm setup” button and then the “Start procedure” button. The radio telescope will perform automatic measurements of Total Power values by varying latitude and longitude offsets (please make sure the object you choose has a good detectability with the SPIDER radio telescope you’re using since this will allow a better calculation of the offset alignment). When the procedure is completed, RadioUniversePRO will complete plotting of the graphs and calculate the best offsets to send to the mount electronics in order to better align to the pointed radio source. When the calculation is performed, pleased press “Send Lat offset” and “Send Long offset” buttons to confirm the values. If you want to save this values as defaults, pleas press the “Save as default” buttons.

TIP: after you complete the first alignment, you can restart a new one to refine it. You can reduce the points number and the step size in order to be more accurate in the offset calculations.

Source Visibilities

Source Visibilities tab lists the most powerful radio sources in the sky. This tab is designed in order to allow you to have a quick idea on the radio sources available that you can point and study with your radio telescope (detection level is different based on the SPIDER radio telescope model you use). In order to point the radio telescope to any of the listed radio sources, please make a mouse double click on the radio source row.



For every radio source are listed

- RA (Right Ascension) coordinate
- DEC (Declination) coordinate
- Az (Azimuth) value
- El (Elevation) value
- Type: star, satellite, AGN (Active Galactic Nuclei), XRAY (X ray source), SNR (Super Nova Remnant), Galaxy, HII (Hydrogen II source), CALIB (Calibration source)
- Note: direction, if it's too low to study, it it's under horizon, transiting or setting.

Every radio source is highlighted with a color:

- Green: visible or transiting (to let you immediately see the objects close to the Zenith)
- Orange: setting
- Red: too low for a detection
- Dark red: under horizon

Gain Calibration

NOTE: Gain Calibration procedure requires the use of the optional “NSGen noise generator”. If you start the Gain Calibration procedure without the optional Noise Generator installed in your SPIDER radio telescope, the shown results won’t be valid.

NOTE: in the latest 1.6.1 version of RadioUniversePRO software the Gain Calibration tab is greyed since we’re implementing new features and improvements in the noise generator use. We plan to release it with the next 1.7 version.

Gain Calibration procedure executes Total Power measurements (by using the proper BBC filters the users select in advance) on a set of radio sources with a known radio flux by literature. These radio sources are listed in the “flux.ctl” file in the RadioUniversePRO folder and this file may be edited and updated based on user requirements. During the Gain Calibration procedure, a proper polinome function allow RadioUniversePRO to calculate the theoretical flux in Jy the radio telescope would record without any atmospheric attenuation or any gain loss because of different factors (antenna deformation because of its weight for example).

Having selected the radio sources to calibrate to, Gain Calibration procedure automatically schedules pointing on them all, on different elevations, always considering the theoretical flux in Jy. The, for every radio sources these Total Power measurements will be performed:

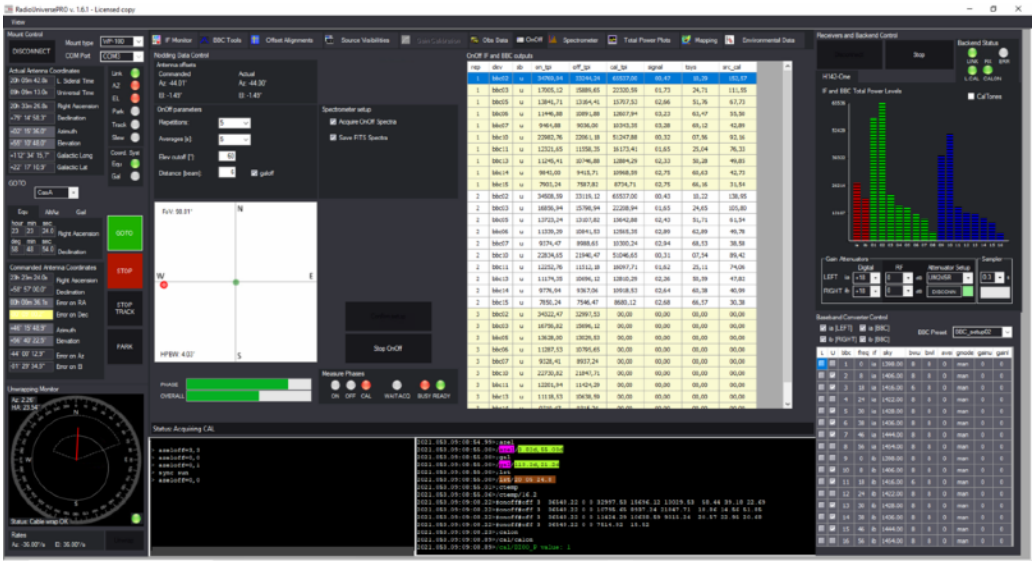
- ON source (on the radio source, with noise generator OFF)
- OFF source (off radio source with noise generator OFF)
- CAL (off radio source with noise generator ON)

Measurements recorded in every step are used to calibrate the noise generator and the radio telescope and this will allow to record antenna temperature and flux measurements.

OnOff

OnOff tab allow you to perform an ON-OFF recording on a radio source. The radio telescope is pointed to the radio source (ON position) and the data is collected. Then it's moved in a position OFF the source and another set of data is collected and used to calibrate the previous one. This way you're able to reduce the radio noise and the effect of external components (like the Earth atmosphere). The ON position is defined by the object selected in the "GoTo" window of the left column of RadioUniversePRO. In the "OnOff parameters" area you can select:

- Repetitions: the number of On-Off measurements the radio telescope has to perform.
- Averages: time in seconds the radio telescope has to stay ON source and OFF course (to record and average data)
- Elev cutoff (°): if the radio telescope is pointed at a radio source with elevation higher than this value, it moves in elevation to reach off position. If it has a lower value, it moves in azimuth.
- Distance (beam): the distance in beams number from ON to OFF position
- galoff: the OFF point position will be calculated in Galactic coordinates. Please select this option if you want to record neutral Hydrogen line in Milky Way plane since the OFF position will be set in "n" distance beams from the galactic plane.

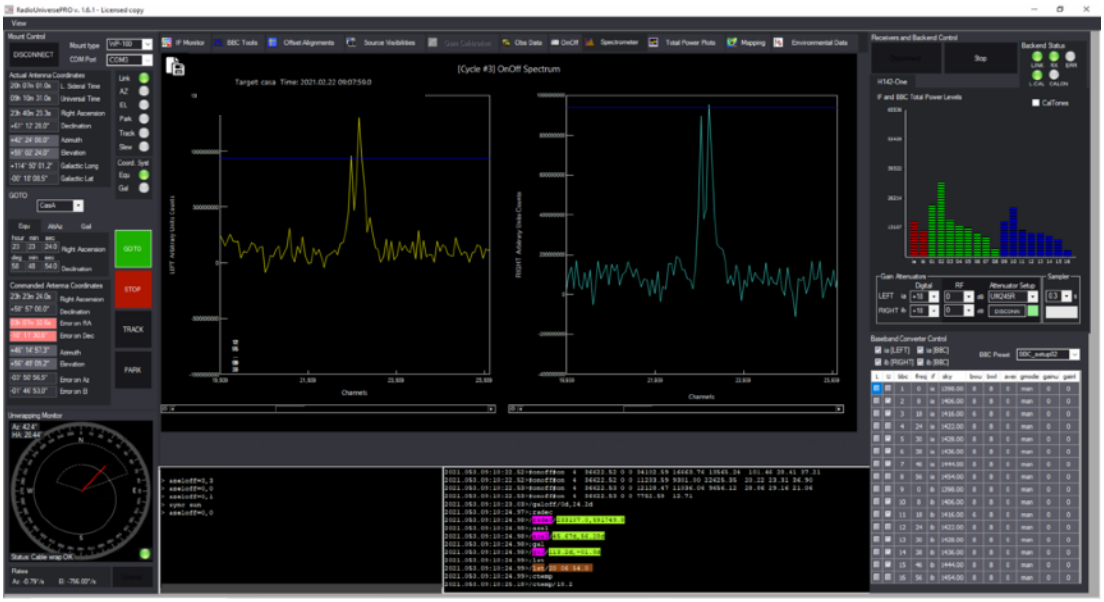


If you want to record also spectra, just select "Acquire OnOff Spectra" option. If you want to save data in FITS format (it will be saved in c:/programs/RadioUniversePRO folder), please select the "Save FITS Spectra" option. Before starting recording data, please click on "Confirm Setup" button and RadioUniversePRO will verify if the input values are corrected. Then click on "Start OnOff" button and the radio telescope will perform the requested measurement. In the central part of the window you can find the "Antenna Offsets - Commanded and Actual". This values indicate how much the radio telescope is off axis during recordings.

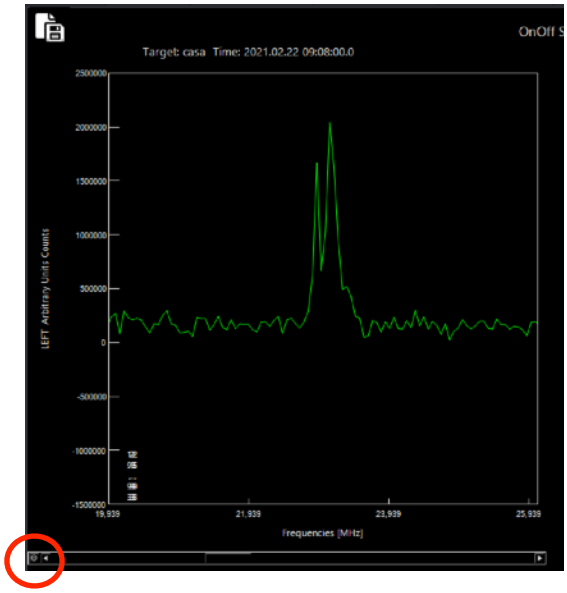
TIP: if you want to record data from weak objects (different from the Sun) we suggest to select 10 repetitions and at least 10 seconds in the Average option in order to increase the signal to noise ratio.

During the ON-OFF sequence, RadioUniversePRO software shows you:

- Phase: duration of each step in ON-OFF procedure
- Overall: duration of the entire ON-OFF procedure
- Measure phases: this indicates if the radio telescope is recording the ON, OFF, or Calibration points. RadioUniversePRO also displays on the graph the position of the OFF point (red) in respect of the ON one (green).



During acquisition, every spectrum is shown in the “Spectrometer” tab, both for left and right polarisations. At the end of acquisition, RadioUniversePRO will automatically perform an average of the data and will display the spectrum.



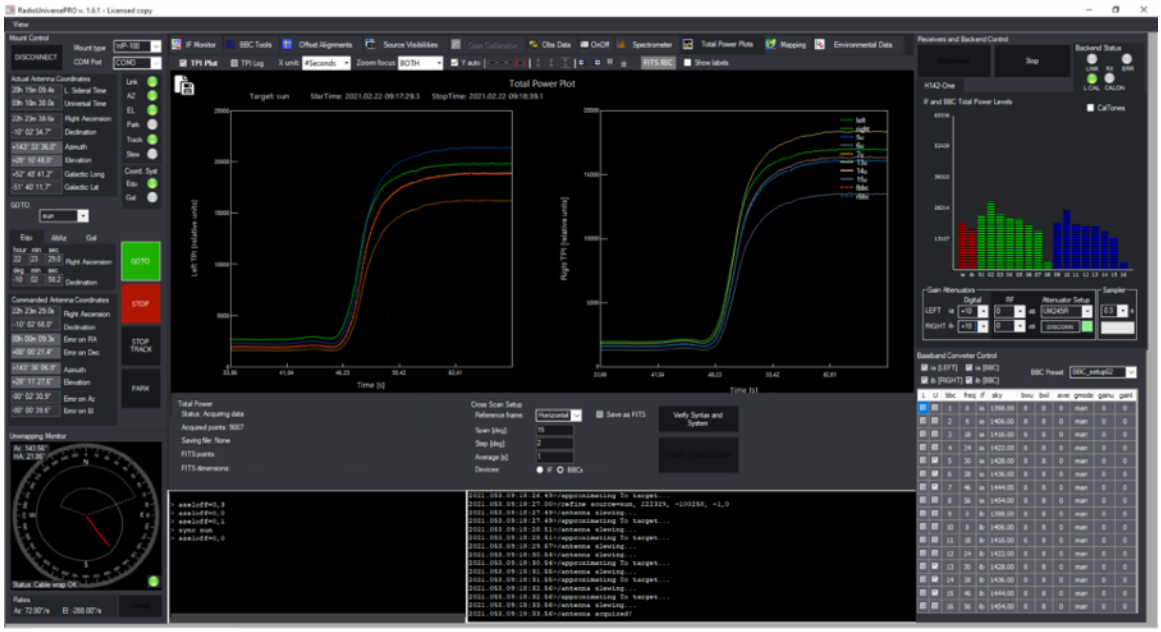
During data acquisition, you can zoom in the spectrum to better visualise parts of it. In order to do so, move the mouse into the spectrum window (you can choose the left or right polarisation) you want to start the zoom in (for example, if you want to better see the neutral Hydrogen line at 1420 MHz put the mouse around 1415 MHz). Then click the left button of the mouse and, keeping the mouse clicked, drag the band up to the higher level you want to visualise (for example 1425 MHz). Release the mouse and the graph will be zoomed in. In order to reset the view, please click on the round button to the left.

At the end of the recordings, your data will be saved in c:/ programs/RadioUniversePRO folder, also in FITS format if you selected the relative option.

TIP: if you want to record neutral Hydrogen line at 1420 MHz, we suggest so set the distance beam at least at 5 in order to avoid to have, in the OFF point, signal from the neutral Hydrogen line.

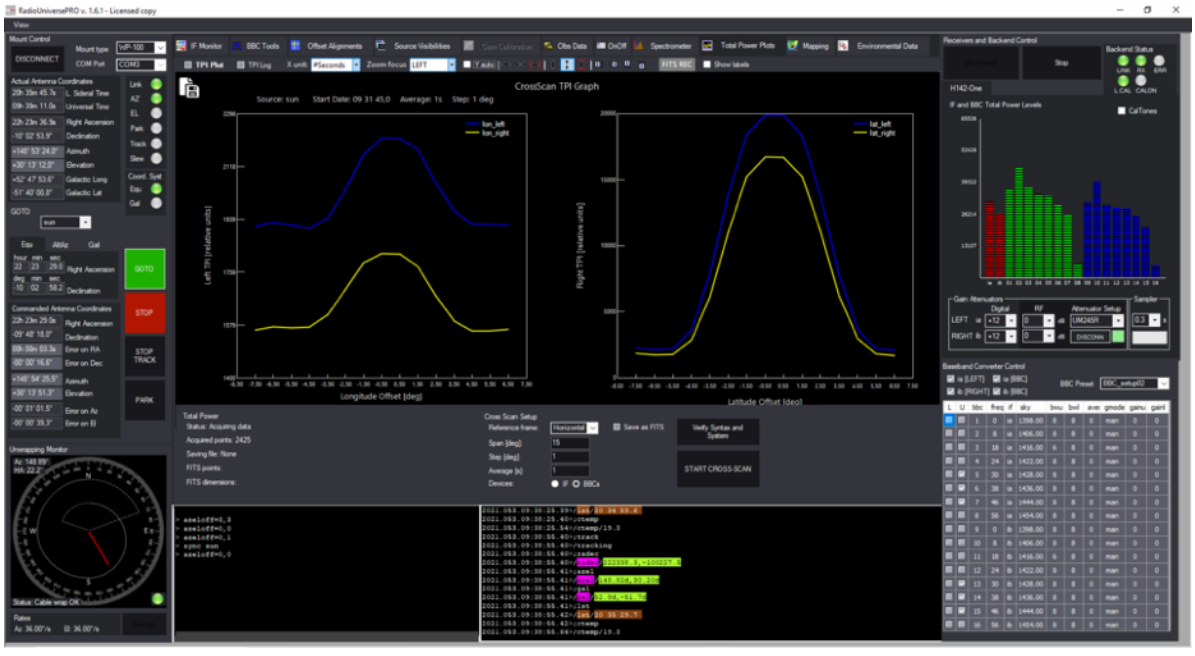
Total Power Plots and Cross Scans

Total Power Plots are the perfect instruments to easily visualise and record the variation of the radio signal flux over time. Just select the “Plot” option and you will see the value in counts for every BBC filter plotted over time. By selecting on "Show Labels”, RadioUniversePRO will add the BBC filters names in the graph.



In the Total Power Plots tab you have the controls that allow the radio telescope to automatically perform a Cross Scan. In the lower right part of the window you can find the settings:

1) Reference frame: horizontal, equatorial or galactic.
2) Span (deg): the length in degrees of the Cross Scan you want to record.
3) Step (deg): the step in degrees between points in the Cross Scan.
4) Average (s): the number of seconds the radio telescope has to record data for every point.
5) Devices: IF (to save the entire bandwidth) or BBC (to save only with the selected BBC filters).

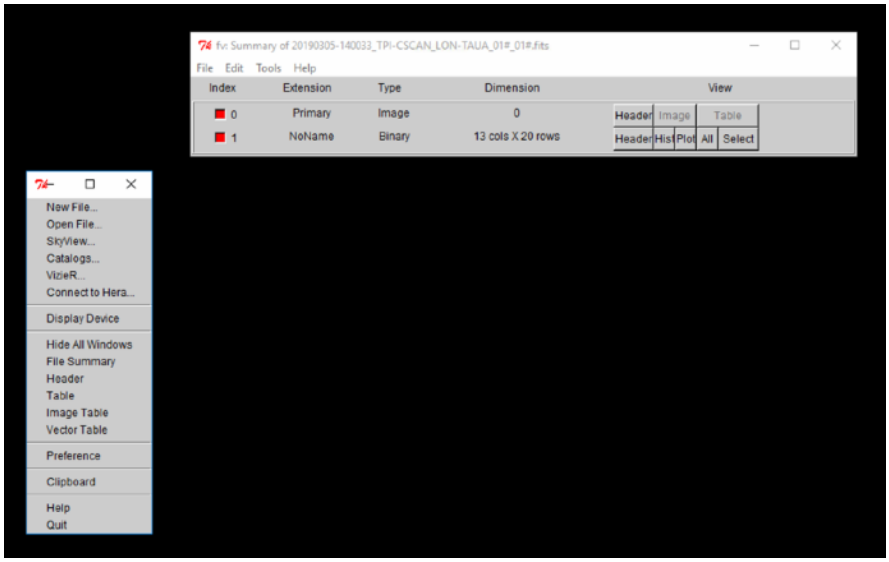


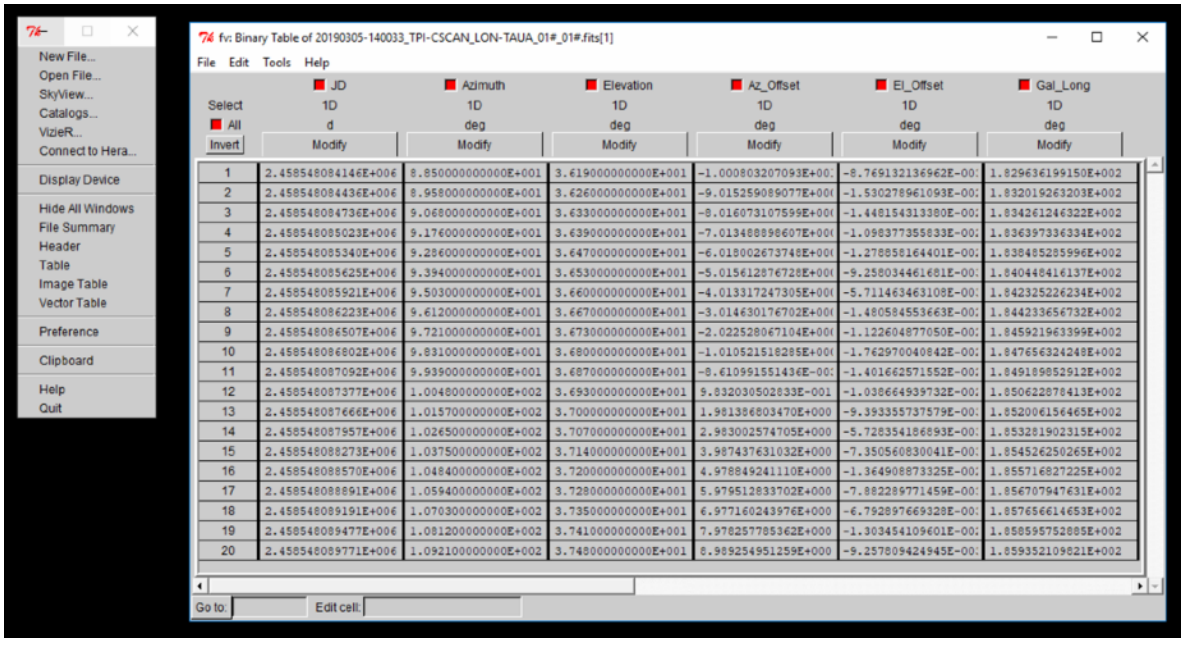
TIP: a Cross Scan recorded on the Sun is a very good and easy way to verify pointing accuracy, focus position and the presence of secondary lobes. Suggested parameters for the Cross Scan on the Sun:

1) Reference frame: horizontal
2) Span (deg): 15
3) Step (deg): 0.3
4) Average (s): 1
5) Devices: BBC

If you want to record data from weaker objects (like Cassiopea A or Cygnus A) you have to increase a lot the Average value, at least 10 seconds, in order to increase signal to noise ratio for every point.

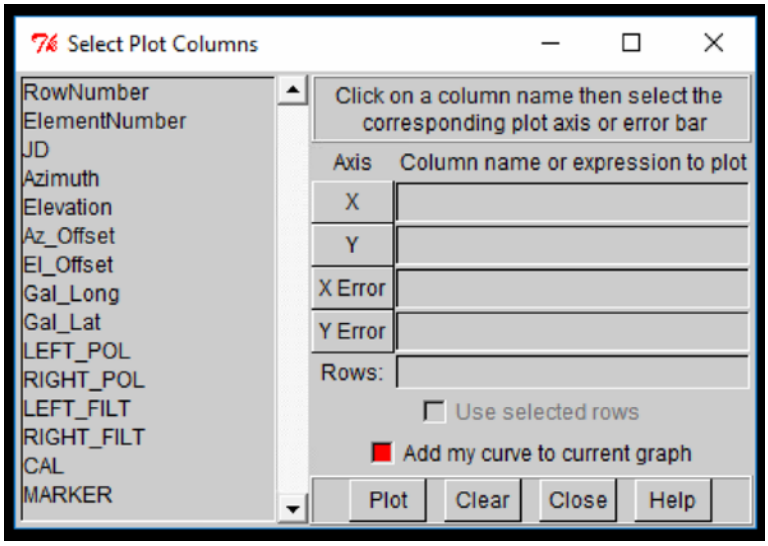
If you select the “Save as FITS” option, RadioUniversePRO will save the Cross Scan in FITS format for a later processing. In order to start Cross Scan acquisition, please press “Verify Syntax and System” button and then the “START CROSS SCAN” button. You will see the data updating in the graph, plotted for the 2 axis. If you select the “Save as FITS” option, you can process data by using the fv FITS Viewer (available for Linux, macOS and Windows) you can download from the page https://heasarc.nasa.gov/ftools/fv/. After you install, please open it, you will see this interface. In order to open your FITS file, please select “New File” and open the FITS file in the c:/programs/ RadioUniversePRO folder. You will see the new Summary window. If you click the ALL button, you will see a new window with all the recorded data. Here you can find these columns:





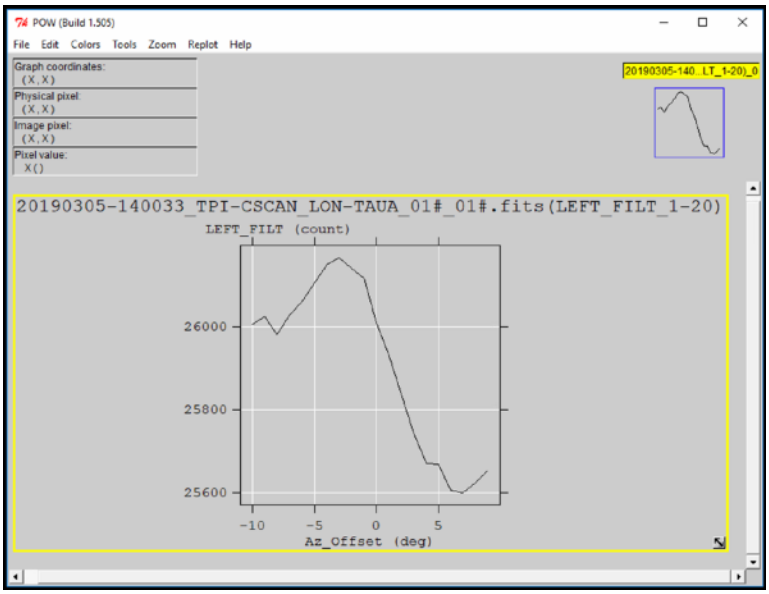
1) JD, time in Julian Date
2) Azimuth
3) Elevation
4) AZ_Offset: offset in Azimuth in respect to the pointed object
5) El_Offset: offset in Elevation in respect to the pointed object
6) Gal_Long: longitude in galactic coordinates
7) Gal_Lat: latitude in galactic coordinates
8) LEFT_pol: total power in counts in the left polarization and entire IF
9) RIGHT_pol: total power in counts in the right polarization and entire IF
10) LEFT_filt: total power in counts in the left polarization and BBC
11) RIGHT_filt: total power in counts in the right polarization and BBC
12) CAL: states if the noise generator is ON or OFF
13) Marker: progressive number of the measured TPI

In order to plot the recorded graph, please click the PLOT button and you will see a new window where you will be able to set the X and Y values of your new graph.



In order to do this, FIRST you have to select the data you want to plot (for example, AZ_Offset) and THEN the button of the graph axis you want to assign (for example X).

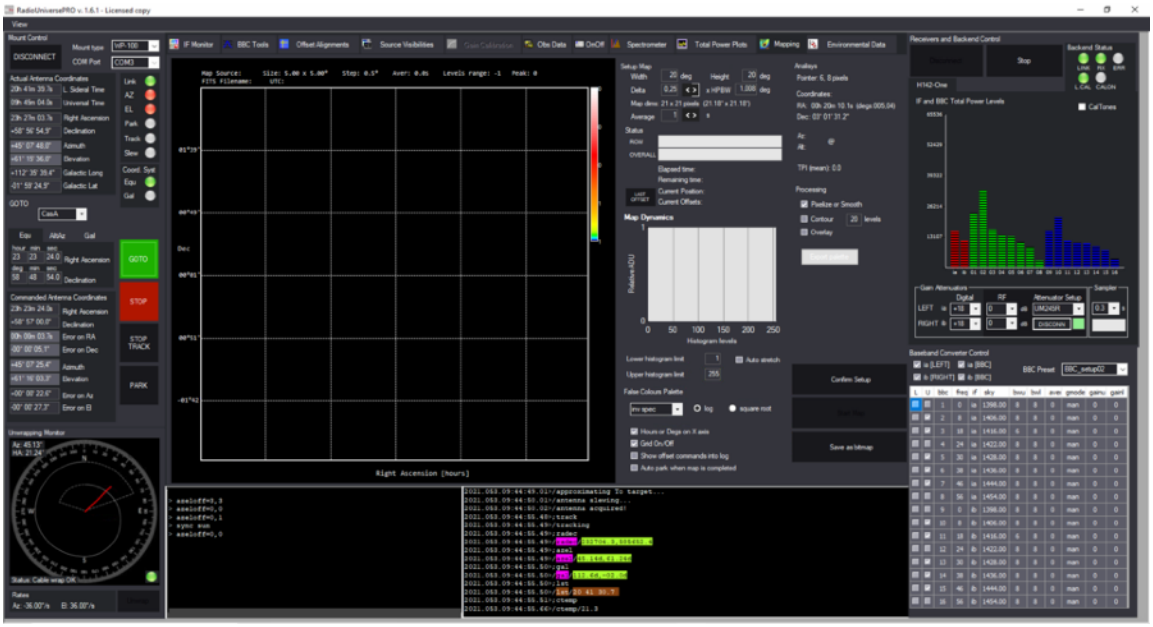
For example, if you want to plot a Cross Scan graph, you can assign AZ_Offset to X and LEFT_filt to Y. Then please press PLOT to create the graph.



Mapping

Mapping tool lets you scan a sky area and convert it into an image map. Select the Mapping tab to reveal Mapping options in the Setup Map area. You can set:

- Width / Height: the side of the Map you want to create.
- Delta: a moltiplicative factor of the HPBW of your radio telescope. This is the distance from pixel to pixel of the map RadioUniversePRO will create. Reduce the value to reduce the antenna movement from pixel to pixel, both in Azimuth and Elevation.
- Average: number of seconds the antenna has to track every pixel and average values (the higher the value, the higher will be the S/N ratio).

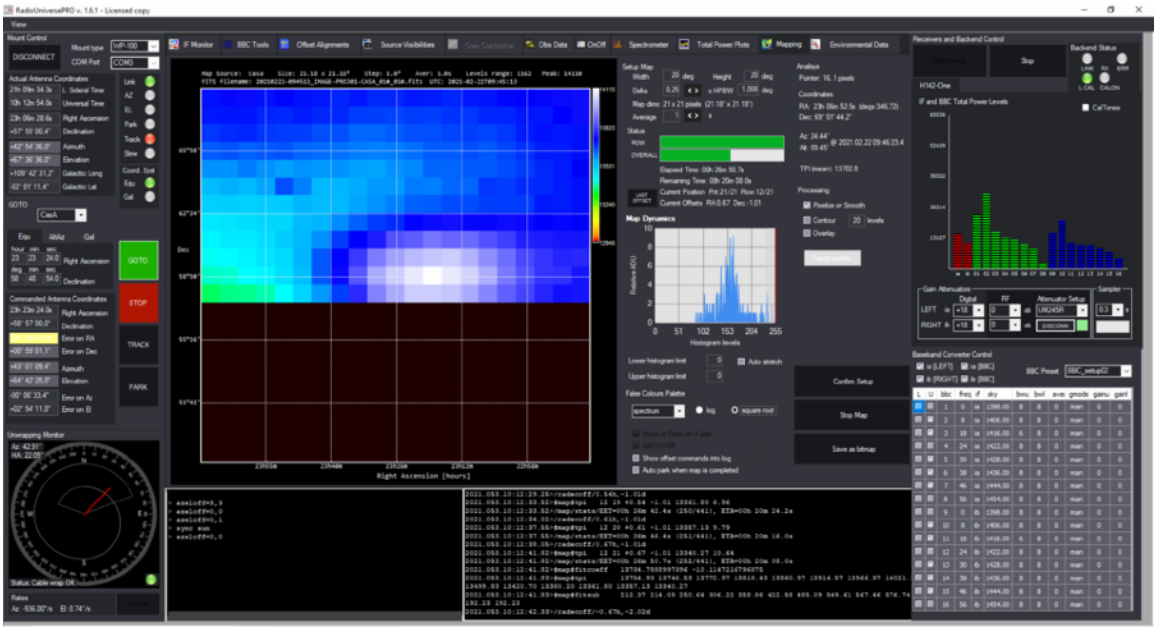


Below the Setup Map area you can find:

- Status: here you will see the progression of every ROW and the OVERALL status during capture.
- Map Dynamics: it shows the histogram of the map.
- False colours palette: you can select the palette you want RadioUniversePRO to use to create the map and the “log” or “square root” methods.

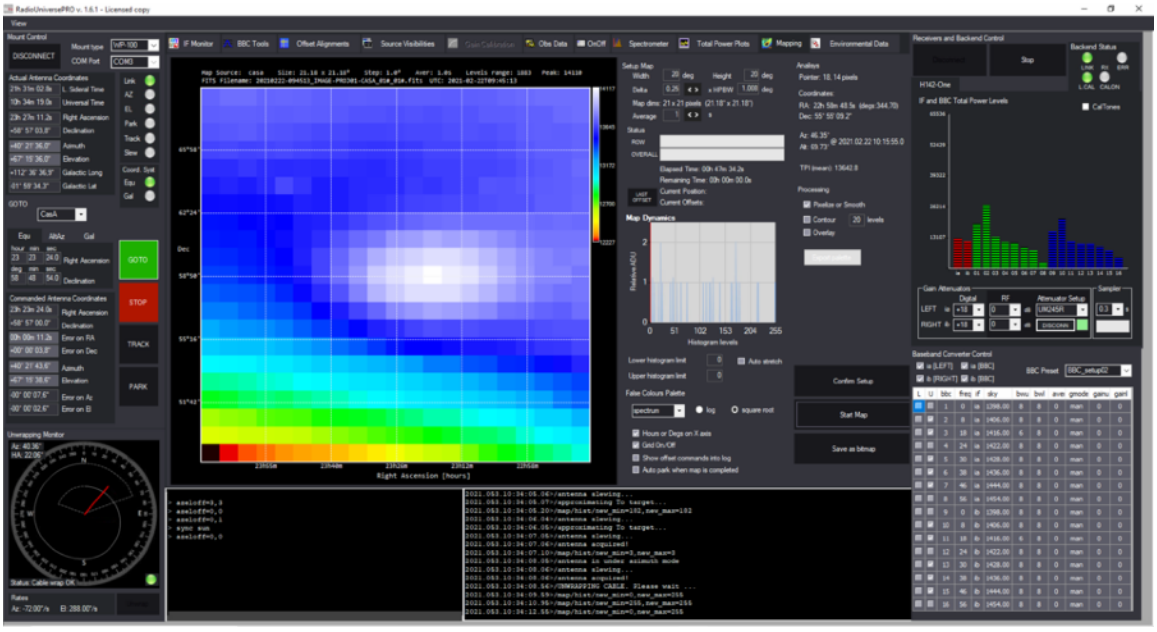
When you set all the parameters, click on “Confirm Setup” to confirm and “Start Map” button to start map recording. You will see the radio telescope moving in different positions and the data will be progressive plotted in the map. The map shows the mapped object name, the map dimension and coordinates in Right Ascension and Declination.

After every row acquisition, RadioUniversePRO will plot the row data and add to the map. During data acquisition, you can change the histogram visualisation to better visualise the signal. In order to do so, move the mouse into the histogram window, click the left button of the mouse and, keeping the mouse clicked, drag the band up to the higher level you want to visualise. Release the mouse and the map will be updated.



When the Map is completed, you can press the “Save as bitmap” button to save it. You will also find the correspondent FITS file in the c:/programs/RadioUniversePRO folder. You also have many options to personalise the recorded map:

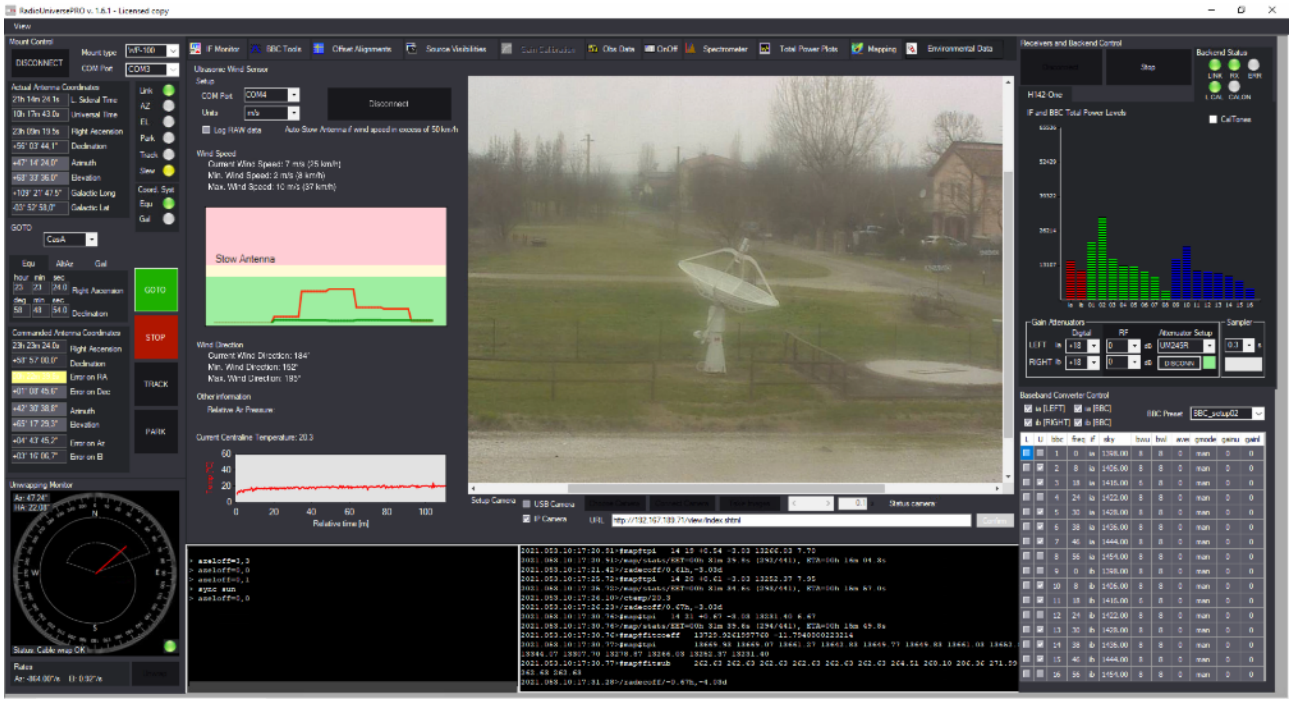
- Pixelize or Smooth
- Contour (you can set the number of levels in the proper field)
- Overlay



TIP: when you want to record a radio map of the Sun you can set an Average value of 1 second. For all the other objects we suggest you to increase it to at least 10 seconds. Please note that a radio map, based on different settings you may choose, may take a long time to be recorded. This means that, before starting the record process for an entire radio map, you have to consider the actual radio telescope position and where the radio telescope will be after the time that is expected to record the entire map. We suggest you to avoid the radio telescope position to be too close to the horizon: it has to be at least 20 degrees from the horizon for the entire acquisition.

Environmental Data

Here you can connect to the Ultrasonic Wind Sensor for SPIDER radio telescopes, view the mount's internal electronics temperature and connect to the camera to view in real time the radio telescope.



In order to connect the optional Ultrasonic Wind Sensor, please select the COM port number that your computer assigns when you connect it to one of the USB ports. Then click on "Connect" button and you will see the data also in the graph. If you use the Ultrasonic Wind Sensor, RadioUniversePRO is able to automatically park the radio telescope in stow position (AZ=270, EL=90) if the wind exceed 50 km/h, in order to reduce wind load and have the radio telescope in safety position.

Below the wind speed graph, you can see also the temperature of the mount's electronic board. RadioUniversePRO is able to automatically park the radio telescope in stow position (AZ=270, EL=90) if the temperature exceed 55°C, in order to prevent problems if the external temperature is too high.

Manual controls for Input Window in RadioUniversePRO

The Input Window allow you to manually write commands that let the SPIDER radio telescope perform a specific action. Move the mouse on the lower line of the Inout Window area and type one of the commands described here, then press ENTER to execute:

NOTE: please type the commands correctly and check the command before pressing the ENTER button (that execute the command) otherwise it could damage the radio telescope.

1) In order to **manually point the radio telescope** to a specific direction you can type this command in Input Window area (then press keyboard ENTER button to launch the command):

source=azel,x,y

This command moves the radio telescope antenna to a coordinates defined position (x=azimuth angle, y=elevation angle) on the sky. For example, if you want to point the SPIDER radio telescope not to a defined radio object position (in this case you can make a double click on radio sources listed in Source Visibilities tab) but to the East and 45° from the horizon, you can simply write:

source=azel,90,45

2) By using the Total Power Plots tab you can measure in real time the variation of their radio flux data recorded by the SPIDER radio telescope by the time. When the receiver is powered on and connected, remember to select the proper BBC tool and then go to Total Power Plots and activate the view by clicking on “Tpi” option on the right column. Point one of the available radio sources (start with the Sun as example) and look at data in the graph. Then use this command:

azeloff=x,y

This command moves the radio telescope away from the radio sources by a defined angle in azimuth (x value) and elevation (y value). So if you write:

azeloff=5,5

The SPIDER radio telescope will move 5 degrees in azimuth and 5 degrees in elevation away from the radio source. Then click on the Total Power Plot tab and you will see the radio flux decreasing. In order to point the radio source, you can use the command

azeloff=0,0

This will reset the off angle values from the computed object position in the sky.

3) In order to **park** the radio telescope in stow position (before turning it off), please use this command:

source=azel,270,90

This will move the radio telescope in stow position (azimuth=270, elevation=90). When the radio telescope is in stow position (you can verify this by looking at it and looking at Actual Antenna Coordinates on the left column), please:

- disconnect the receiver by pressing Stop and Disconnect buttons on the right column
- Disconnect the mount by pressing the Disconnect button on the left column
- Exit from RadioUniversePRO software
- Turn off your computer and screen with the remote

4) In order to record a Cross Scan of an object, after having the SPIDER radio telescope pointed at a radio source (for example by using the Source Visibilities tab), you can also use this command:

crossscan=hor,5,1,2,if,1

The syntax of the command is

crossscan=[subscanFrame],[span],[step],[average],[devices],[save]

there:

subscanFrame = hor,equ,gal

span = the number in degrees that defines the length of the cross scan

step = the number in degrees that defines distance between two points in the cross scan

average = the number in seconds that defines how many seconds of integration are set for every cross scan point

devices = this can be “if” if you want to use the entire “if” for the totalpower or “bbcs” to use the bbc based on the actual setting of the filters

save = number that can be 1 or 0 and defines if you want to save cross scan data in FITS format