ShowTel: a solar alarm system and real-time monitoring tool for the INAF radio telescopes

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Abstract

This technical note describes the open-source Python package ShowTel and guides the user/observer to use this tool properly. ShowTel – successfully tested – is aimed at the real-time monitoring of the operations of a radio telescope during an observing session, such as (1) the status of the antenna control system, (2) general information about the observing session, (3) the angular distance between the Sun (and the Moon) and the radio telescope pointing, (4) the sky position of the Sun, Moon and the astrophysical object under observation, and (5) the Radio Frequency Interference (RFI) of the sky region pointed by the radio telescope, at the running observing frequency. ShowTel appears as an interactive widget that compactly and smartly shows in real-time all this information to the observer, to (1) mitigate unpleasant inconveniences during observation campaigns, and (2) check the proper working of the radio telescope. These inconveniences are reported to the observer thanks to an efficient alarm system, whose sound is audible also when the observer is temporarily far away from the control room of the radio telescope. This Python package is designed for the observing operations of the Sardinia Radio Telescope (SRT), but it can be easily suitable – with a specific tuning – also for other radio telescopes of the INAF Network (such as the Medicina "Gavril Grueff" Radio Telescope and the Noto Radio Telescope) in the near future. ShowTel represents a crucial tool to complete – and not to replace – the Sun avoidance system soon available in the DISCOS control system of the INAF radio telescopes, to automatically prevent the direct pointing of the antenna in the Sun (or in its proximity) during no-solar observation sessions.

ShowTel will be enhanced through the upgrading of SRT with the new cryogenically cooled receivers, operating in the frequency range 33 – 116 GHz, in the context of the National Operative Programme (Programma Operativo Nazionale-PON); this project will provide in the near future an upgrading with the new receivers up to 116 GHz also for the Grueff and Noto Radio Telescopes, to provide the scientific community with the instrumentation suited to the study of the Universe at high radio frequencies.

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Contents

1 Introduction

The real-time monitoring of the operations of a radio telescope during an observing session is crucial to avoid – or at least help to prevent – unsafe situations for the antenna. In this context, Sun avoidance is a technical requirement in radio (and not only) facilities to prevent the direct pointing of the antenna in the Sun (or in its proximity), during no-solar observations. This requirement plays a crucial role, especially in all those radio telescopes not exclusively suited for solar observations, preventing possible damage to the instrumentation – caused by the strong solar radiation incident on the receiver – not properly protected by a specific thermal and electrical assessment of the set-up. At the instrumental level, direct pointing toward the Sun generates a non-linear response in the receiving chain, resulting in saturation of the hot secondary amplification stage (particularly in the low-noise amplifiers, LNA). This makes the scientific data unusable for the observer. Due to the behaviour of the brightness temperature of the Sun at various radio frequencies (see for example [18, 11]) and the compression point of the LNAs ($\sim$ 4 dBm[1]), the problems in the receiving chain are more marked when the observing frequency is lower than 2 GHz. At the time of writing, for the INAF radio telescopes there is no accurate technical analysis about the safety of the receivers in terms of their pointings in the proximity of the Sun, but only verbal prescriptions about the minimum threshold of angular distance between the Sun and the pointing of the receiver, mainly based on the characteristics of the LNA of the receivers. For this reason, the Sun avoidance utility tool is in the advanced stage of implementation in the DISCOS control software for the INAF radio telescopes[2].

The open-source Python package ShowTel[3], described in this technical note, is designed for the real-time monitoring of the operations of a radio telescope during an observing session, in particular: (1) the status of the antenna control system, (2) general information about the observing session, (3) the angular distance between the Sun (and the Moon) and the radio telescope pointing, (4) the sky position of the Sun, Moon and the astrophysical object under observation, and (5) the Radio Frequency Interference (RFI) of the sky region pointed by the radio telescope, at the running observing frequency. ShowTel also aims to complete and enhance – and not to replace – the Sun avoidance system soon available in the DISCOS control system. This Python package is suited for the observing operations of the Sardinia Radio Telescope (SRT), with the prospect of making it usable – with a specific tuning – also for the other radio telescopes of the INAF Network (such as the Medicina "Gavril Grueff" Radio Telescope and the Noto Radio Telescope)[4]. ShowTel – thanks to its interactive widget, successfully tested – compactly and smartly displays all this information to the observer in real-time mode. This widget contributes not only to mitigate unpleasant (and possibly harmful) inconveniences during observation campaigns, but also to check the proper working of the radio telescope. Such inconveniences are signaled to the observer thanks to an efficient alarm system, whose sound is audible even when the observer is temporarily far away from the SRT control room.

This Python package will be suitable for the scientific community – with the appropriate arrangements – also for the real-time monitoring of the new forthcoming cryogenically cooled

[1] Private communication.

[2] The implementation at SRT is called DISCOS-NURAGHE. For further details about this control system, see the relative INAF documentation at this link: https://discos.readthedocs.io/en/latest/user/index.html.

[3] This tool is available in the GitHub developer platform at this link: https://github.com/mmarongiu/ShowTel

[4] https://www.radiotelescopes.inaf.it/

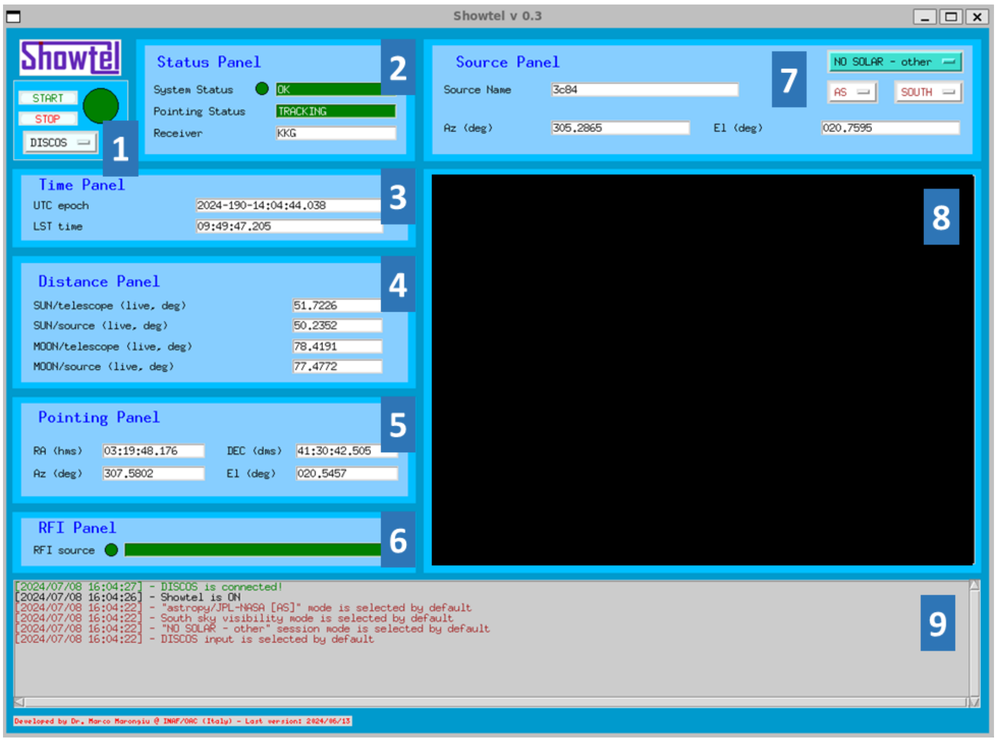

Figure 1: *Widget of* ShowTel, *Python package aimed at monitoring the observing session in real-time at SRT site. This Python package is composed of nine panels, labelled as follows: 1 for the switch & connection panel, 2 for the status panel, 3 for the time panel, 4 for the distance panel, 5 for the pointing panel, 6 for the RFI panel, 7 for the source panel, 8 for the sky position & visibility panel, and 9 for the log panel.*

receivers at SRT, operating in the frequency range 33 – 116 GHz (e.g., [12]), in the context of the National Operative Programme (Programma Operativo Nazionale-PON)[5] [7]. This project will soon provide an upgrade with the new receivers up to 116 GHz also for the Grueff and Noto Radio Telescopes[6] [2], to provide the scientific community with the instrumentation suited to the study of the Universe at high radio frequencies.

An important impulse at the development of ShowTel is given by two solar projects (SunDish[7] and Solaris[8]), both supervised by A. Pellizzoni. These solar projects are aimed at the imaging and monitoring of the solar atmosphere at radio frequencies through single-dish observations. For the SunDish project, the observing frequency ranges from 18 to 26.5 GHz, but in perspective it will reach 116 GHz thanks to the PON receivers. The observing frequency for the Solaris project is ~ 100 GHz.

This technical note is organised as follows. The description of the panels that compose the widget of ShowTel is reported in Section 2. The usage, the Python details, and the output of this Python package are reported in Sections 3, 4, and 5, respectively. Releases, remarks, curiosities, and future developments of ShowTel are reported in Sections 6, 7, 8, and 9, respectively. The system requirements, the download, and the installation procedure of ShowTel are described in the Appendix (A and B).

[5] https://sites.google.com/a/inaf.it/pon-srt/home

[6] https://indico.ict.inaf.it/event/1515/contributions/9080/attachments/4392/9080/PON_SRT_AUDIZIONE_31MAY21.pdf

[7] https://sites.google.com/inaf.it/sundish

[8] https://sites.google.com/inaf.it/solaris

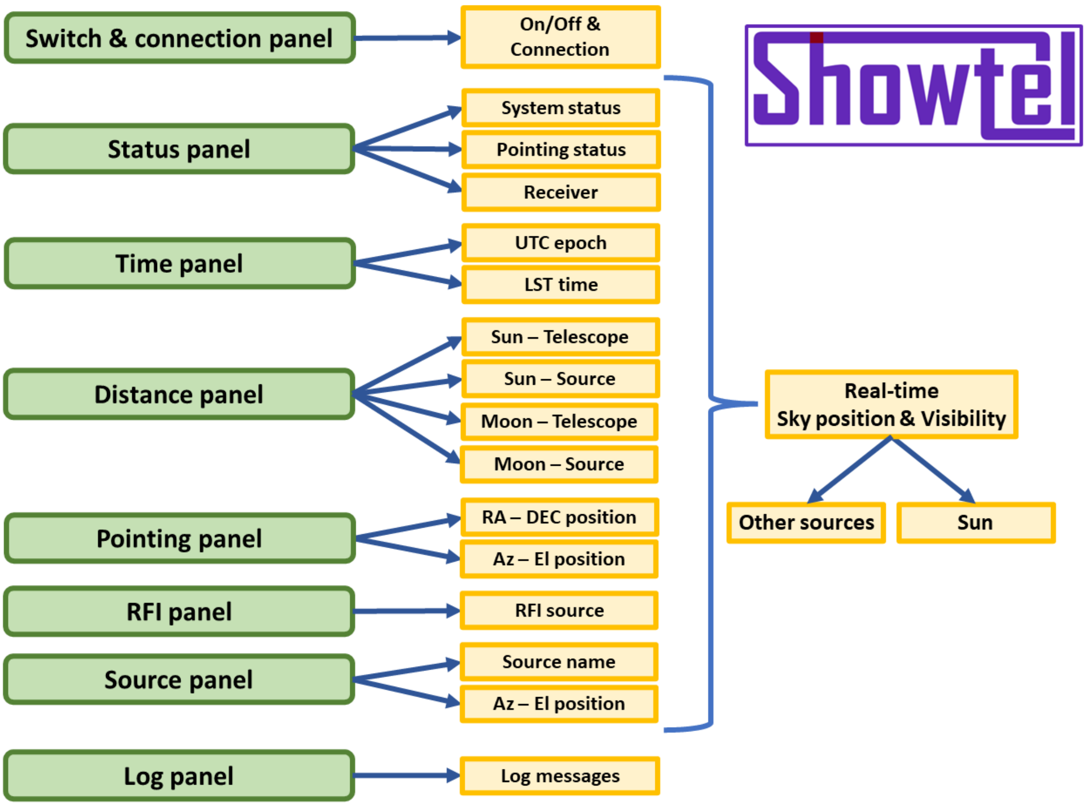

Figure 2: *Diagram of the* SHOWTEL *operation. The official logo of* SHOWTEL *is displayed at the top right.*

2 The interactive widget of SHOWTEL

SHOWTEL appears to the user/observer as a widget (Fig. 1) containing several panels, accurately described in this section. This Python Package receives as input every N seconds, where N can be set up from the user (default value: 5 s), only a dictionary containing the information in real-time of DISCOS antenna control system (Sect. 4). A simplified scheme of the SHOWTEL operating is shown in Fig. 2.

2.1 Switch & connection panel

This panel (labelled as 1 in Fig. 1) contains the switch of SHOWTEL, the drop-down menu for selecting the kind of connection to the control system, and the control light that indicates if the SHOWTEL is connected with the control system. The SHOWTEL switch is composed of two buttons: Start (in green font character) and Stop (in red font character). The user can turn on or off SHOWTEL by clicking the corresponding button. The button for selecting the kind of connection to the control system allows to choose two different approaches:

1. **DISCOS** ⇒ this option allows to connect directly SHOWTEL to the DISCOS control system;

2. **SEADAS** ⇒ this option allows to connect SHOWTEL to DISCOS through the SRT ExpAnded Data Acquisition System (SEADAS) management tool [5, 6] – dedicated to pulsar observations[9] [4] – used as a middleware.

[9] http://www.srt.inaf.it/media/uploads/astronomers/pulsarobssrt-v0.3.pdf

The control light indicates if the ShowTel is connected (green light) or disconnected (red light) with the control system. The yellow light indicates that ShowTel receives the information from DISCOS, but there are runtime problems. In addition to the control light, the connection status is monitored by a voiced alarm.

2.2 Status & Receiver panel

This panel (labelled as 2 in Fig. 1) shows (1) the status in real-time of the DISCOS control system, and (2) the receiver in use. In particular:

- **System status** comprises a box panel and a control light. These elements are green for "OK" status, yellow for "`WARNING`" status, and red for "`FAILURE`" status. The failure status also includes a voiced alarm.
- **Pointing status** consists of a box panel. This box is green for "`TRACKING`" status, and yellow for "`SLEWING`" status.

These DISCOS statuses are displayed in this panel for a fast check from the user/observer.

2.3 Time panel

This panel (labelled as 3 in Fig. 1) shows the epoch in real-time where the information is taken from the control system of the antenna. The epoch is displayed both in Coordinated Universal Time (UTC) format (`yyyy-ddd-hh:mm:ss.fff`) and Local Sidereal Time (LST) format (`hh:mm:ss.fff`).

2.4 Distance panel

This panel (labelled as 4 in Fig. 1) displays the angular distances (in units of degrees) in real-time between:

- Sun and the radio telescope;
- Sun and the astrophysical source;
- Moon and the radio telescope;
- Moon and the astrophysical source.

At the time of writing, in the absence of an accurate analysis concerning the Sun avoidance techniques for the INAF radio telescopes, we provisionally set up three safety regions for the pointing monitoring in real-time:

1. **Standard region** $\Rightarrow$ the angular distance between the Sun and the pointing of the radio telescope is greater than (a) 4° (for K-band), (b) 5° (for C-band), (c) 8° (for L-band), and (d) 12° (for P-band);
2. **Warning region** $\Rightarrow$ the angular distance between the Sun and the pointing of the radio telescope ranges between (a) 4° and 2° (for K-band), (b) 5° and 2.5° (for C-band), (c) 8° and 4° (for L-band), (d) 12° and 6° (for P-band);
3. **Critical region** $\Rightarrow$ the angular distance between the Sun and the pointing of the radio telescope is less than (a) 2° (for K-band), (b) 2.5° (for C-band), (c) 4° (for L-band), and (d) 6° (for P-band).

Figure 3: *The three safety regions displayed in the distance panel of the* ShowTel *widget (left, standard region; centre, warning region; right, critical region).*

The definition of these safety regions is strictly dependent on the behaviour of the solar radius ($R_\odot \sim 0.3$ deg; [11]) and the brightness temperature of the Sun (see for example [18, 11]) in the frequency domain of SRT, and the technical characteristics of the SRT receivers. In this context, we defined the threshold values of the critical region assuming N times the angular distance between the main and the third lobe of the beam pattern of the SRT receivers, corresponding to a difference of ~ -30 dB of amplitude ([14, 17]). We conservatively assumed $N = 50$ for the K-band, $N = 18$ for the C-band, $N = 4$ for the L-band, and $N = 1.7$ for the P-band. These safety regions are designed to ensure a linear response in the receiving chain, making the data suitable for scientific use. A first estimation of the threshold value for the critical region (10°) is reported in the manual of CASTIA [16], a software package able to check radio source visibilities at a given date from any of the three Italian radio telescopes of the INAF Network[10]. Our threshold values are compatible with those of other radio facilities, such as the Very Large Array (VLA)[11], the Very Long Baseline Interferometry (VLBI)[12], the IRAM radio telescopes[13], the Arizona Radio Observatory[14].

Following our distance prescription, if the angular distance between the Sun and the pointing of the radio telescope is included in the Standard region, the relative background of the box is white (Fig. 3, left). If this angular distance ranges in the Warning region, yellow fills the background of the box (Fig. 3, centre). Finally, if this angular distance is included in the Critical region, the relative background of the box is red (Fig. 3, right). In the latter case, ShowTel triggers an audible alarm to draw attention to the observer.

2.5 Pointing panel

This panel (labelled as 5 in Fig. 1) shows the pointing coordinates for SRT, both in celestial coordinate (RA: `hh:mm:ss.fff`; Dec: `dd:mm:ss.fff`) and altazimuth (Az/El: `ddd.fff` degrees) format.

2.6 RFI panel

This panel (labelled as 6 in Fig. 1) displays if the antenna heads towards a region of the sky suffered by the RFI phenomena, at the running observing frequency. These RFI sources are monitored and collected by a specific team at SRT[15]. If the pointed region of the sky does not suffer from RFI phenomena (normal case), the box and the control light are green. Conversely, the box and the control light are yellow if the pointed region of the sky suffers from RFI phenomena (RFI case). The yellow box shows the name of the RFI source and the internal availability of the RFI spectrum. In case of problems during the observing

[10] http://www.ira.inaf.it/Observing/castia/site/
[11] https://science.nrao.edu/facilities/vla/docs/manuals/obsguide/dynsched/avoiding-the-sun
[12] https://www3.mpifr-bonn.mpg.de/div/vlbi/globalmm/tech.html
[13] https://www.iram.fr/IRAMFR/GILDAS/doc/pdf/astro.pdf
[14] https://aro.as.arizona.edu/?q=sun-avoidance
[15] http://www.srt.inaf.it/project/rfi-monitoring/

session in the antenna (or during the imaging procedure), the RFI spectrum – labelled with the capital letter S after the name of the RFI source – can be useful to establish (through direct comparison) if this spectrum pollutes the astronomical data at the relative observing frequency. The RFI spectrum is available for the observer only by contacting the RFI team at SRT site. For each observing frequency of SRT, the sky position & visibility panel (see Sect. 2.8) displays possible RFI regions in blue.

2.7 Source panel

This panel (labelled as 7 in Fig. 1) shows the name of the source observed with the radio telescope, with its altazimuth position (Az/El: `ddd.fff` degrees).

The source panel contains three buttons:

- **Source radar** (on the top right) allows to select the kind of monitoring in the Sky position & visibility panel (Sect. 2.8). If NO SOLAR - OTHER is selected, ShowTel activates (1) the alarm system for the distances, as described in Sect. 2.4, and (2) the generic monitoring in real-time in the Sky position & visibility panel (Sect. 2.8). On the other hand, if SOLAR is selected, ShowTel disables (1) the alarm system for the distances, as described in Sect. 2.4, and activates (2) the solar monitoring in real-time in the Sky position & visibility panel (Sect. 2.8). The solar observing mode at SRT (and Grueff radio telescope) adopts a specific thermal and electrical assessment of the set-up, to prevent damage and saturation of the receivers during solar exposures [13] (default selection: NO SOLAR - OTHER).

- **Ephemeris quality** (under the Source radar button, on the left) allows to select the accuracy of the ephemerides both of the Sun and the Moon. If AS is selected, ShowTel calculates the distances and visibilities using an accurate Python ephemeris system, based on the ASTROPY library [1]. On the other hand, if SK is selected, ShowTel calculates the distances and visibilities using a very high-quality (HQ) Python ephemeris system, based on the SKYFIELD library[16] (default selection: AS).

- **Sky grid option** (under the Source radar button, on the right) allows to select the more comfortable sky grid for the observer in the sky position monitor (Sect. 2.8). If North is selected, ShowTel displays the sky position monitor centered at 0° in azimuth (at North); this graphical representation is useful when the declination of the observing source is higher than the antenna latitude. If South is selected, ShowTel displays the sky position monitor centered in azimuth at 180° (at South); this graphical representation is useful when the declination of the observing source is lower than the antenna latitude. (default selection: South).

2.8 Sky position & visibility panel

This panel (labelled as 8 in Fig. 1) displays the sky position & visibility of several sources (with their trajectories), and the pointing of the radio telescope in real-time. As deeply described in the Source radar button in Sect. 2.7, this panel can display two different kinds of sky monitoring (Fig. 4): generic mode (NO SOLAR - OTHER option), and solar mode (SOLAR option).

The sky position monitor is located at the upper part of the panel, and displays in the altazimuth coordinates:

[16] http://rhodesmill.org/skyfield/

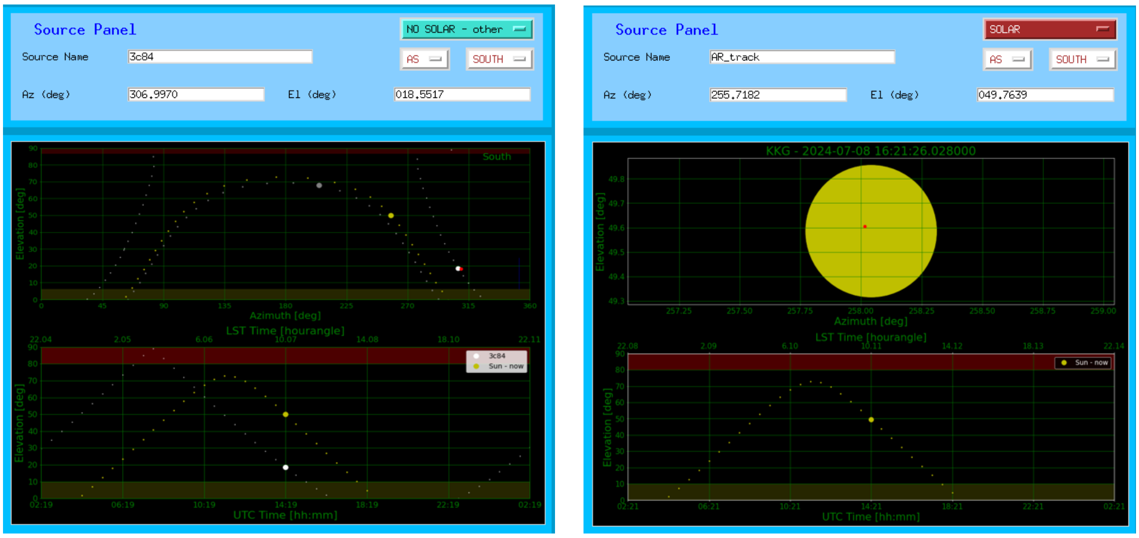

Figure 4: *Sky position & visibility panel for (left) the generic mode, selecting the* NO SOLAR - OTHER *option in the drop-down menu of the Source panel, and (right) the solar mode, selecting the* SOLAR *option.*

- (`generic mode`) the sky position in real-time of the Sun (yellow full circle), Moon (grey full circle), and the observing source (white full circle), with respective trajectories (dotted lines);
- (`solar mode`) the sky position in real-time of the Sun (yellow full circle), with the canonical value at optical frequencies of the solar photosphere radius $R_{\odot,opt}$ accepted by the International Astronomical Union (IAU; [9, 15]), corresponding to 695.66 ± 0.14 Mm (959.16 ± 0.19 arcsec; [8]);
- (`generic mode - solar mode`) the pointing of the radio telescope in real-time (red full circle).

As described in Sect. 2.6, this monitor displays the RFI regions in blue.

The visibility plot is located at the bottom part of the panel. This plot displays the time evolution in elevation of the Sun (yellow dotted line, both for the generic and the solar modes) and the observing source (white dotted line, only for generic mode). The real-time elevation of these sources is displayed with a full circle (yellow for the Sun, and white for the observing source). The red-shaded area denotes elevations higher than the antenna limit ($\gtrsim 80°$). The yellow-shaded area indicates elevations lower than the site horizon ($\lesssim 10°$).

2.9 Log panel

This panel (labelled as 9 in Fig. 1) displays the log messages produced by SHOWTEL. In particular, the alarm system is connected with red messages in this panel, warning messages are written in yellow, system messages are written in brown, the connection status of DISCOS is labelled in green, and the default set up of this Python package is written in black.

3 Using ShowTel

Using ShowTel is very simple, thanks to an intuitive widget (Fig. 1). As described in the Appendix. B, this widget appears by issuing the command `python showtel.py` (or `run showtel.py` from the `ipython` environment). The execution of ShowTel requires some simple configuration actions by the observer:

- **"Activate the package"** in the Switch & connection panel, labelled as 1 in Fig. 1 and deeply described in Sect. 2.1;
- **"Selecting the kind of connection to the control system"** (between DISCOS and SEADAS) in the Switch & connection panel, labelled as 1 in Fig. 1 and deeply described in Sect. 2.1 (default selection: DISCOS);
- **"Selecting the kind of observation"** (between SOLAR and NO SOLAR) in the Source panel, labelled as 7 in Fig. 1 and deeply described in Sect. 2.7 (default selection: NO SOLAR);
- **"Selecting the kind ephemeris quality"** (between SK and AS) in the Source panel, labelled as 7 in Fig. 1 and deeply described in Sect. 2.7 (default selection: AS);
- **"Selecting the sky grid"** (between North and South) in the Source panel, labelled as 7 in Fig. 1 and deeply described in Sect. 2.7 (default selection: South).

Once the configuration is set up, ShowTel is ready to monitor the observations conducted at SRT in real-time, in order to prevent damages at the instrumentation caused by pointings of the antenna near close to the Sun. Thanks to the alarm system, during the observation sessions at SRT the observer can become aware of problems – and then intervene – also when it is far away from the control room.

ShowTel has been successfully tested on the DISCOS Simulators framework [3], designed to provide a means to integrate several hardware simulators of the three Italian radio telescopes (especially SRT) under the same environment. Solar observations with the INAF radio telescopes can be carried out following the call of proposal instructions reported on the website of the INAF radio telescopes.

4 Composition of ShowTel

ShowTel consists in a sophisticated Python architecture (Fig. 5), composed of several environments:

showtel_connection.py This file contains the functions necessary to connect ShowTel with DISCOS control system, and to check the connection status in real-time. At the time of writing, this connection is established through a Low-level networking interface (socket)[17], but we do not exclude that a more performing connection system for our needs may be implemented soon. To date DISCOS (direct connection) and SEADAS (middleware connection) are available for the connection with DISCOS. As described in the Appendix B, before using ShowTel for the first time, the user has to insert the correct IP address and number port of the socket connection with DISCOS.

[17] https://docs.python.org/3/library/socket.html

showtel_discos.py This file includes the function to create a Python dictionary that contains all the information in real-time of DISCOS antenna control system. DISCOS communicates this information via SOCKET (SENDALL option[18]) through the ANTENNAPARAMETERS command. To date, this dictionary contains the following information:

- 'SysUTC' ⇒ current Coordinated Universal Time (UTC) of DISCOS in format (`yyyy-ddd-hh:mm:ss.fff`);
- 'SystemStatus' ⇒ current status of DISCOS (`OK`, `WARNING` or `FAILURE`);
- 'SourceName' ⇒ name of the current observed source;
- 'Azimuth' ⇒ current azimuth position (in units of decimal degrees) of the antenna pointing;
- 'Elevation' ⇒ current elevation position (in units of decimal degrees) of the antenna pointing;
- 'RightAscension' ⇒ current right ascension position (in units of hour angle degrees) of the antenna pointing;
- 'Declination' ⇒ current declination position (in units of degrees) of the antenna pointing;
- 'GalacticLongitude' ⇒ current Galactic longitude position (in units of decimal degrees) of the antenna pointing;
- 'GalacticLatitude' ⇒ current Galactic latitude position (in units of decimal degrees) of the antenna pointing;
- 'CommandedAzimuth' ⇒ commanded azimuth position (in units of decimal degrees) of the antenna pointing;
- 'CommandedElevation' ⇒ commanded elevation position (in units of decimal degrees) of the antenna pointing;
- 'AzimuthError' ⇒ difference (in azimuth position) between the commanded and the current antenna pointing;
- 'AzimuthCorrection' ⇒ azimuth correction (in units of decimal degrees) applied by the pointing model;
- 'AzimuthOffset' ⇒ azimuth offset as read from schedule (in units of decimal degrees);
- 'ElevationError' ⇒ difference (in elevation position) between the commanded and the current antenna pointing;
- 'ElevationCorrection' ⇒ elevation correction (in units of decimal degrees) applied by the pointing model;
- 'ElevationOffset' ⇒ elevation offset as read from schedule (in units of decimal degrees);
- 'RefractionElevationCorrection' ⇒ additional correction to elevation (in units of decimal degrees) applied by the refraction model contribution;
- 'RaOffset' ⇒ right ascension offset as read from schedule (in units of decimal degrees);

[18] This SOCKET method continues to send data from bytes until either all data has been sent or an error occurs.

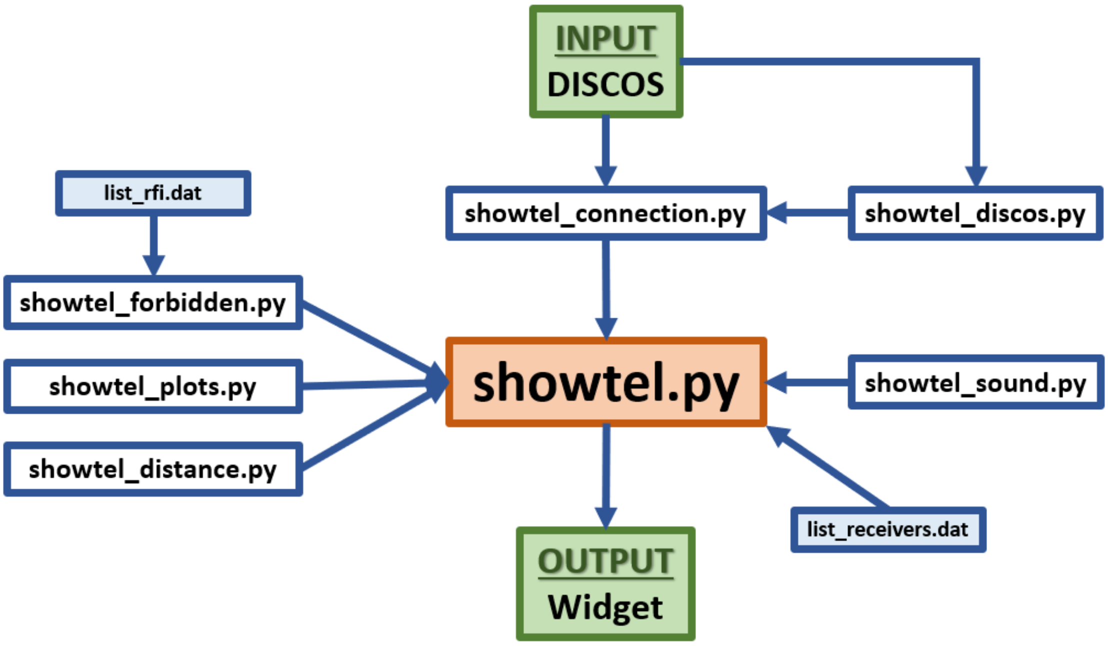

Figure 5: *Diagram of the Python package* SHOWTEL. *Input/Output are labelled in green.*

- 'DeclOffset' ⇒ declination offset as read from schedule (in units of decimal degrees);
- 'GalLongitudeOffset' ⇒ Galactic longitude offset as read from schedule (in units of decimal degrees);
- 'GalLatitudeOffset' ⇒ Galactic latitude offset as read from schedule (in units of decimal degrees);
- 'ReceiverCode' ⇒ code of the receiver in use at the radio telescope;
- 'LOFrequency' ⇒ Local Oscillator frequency (in units of MHz) of the receiver in use;
- 'PointingStatus' ⇒ current status of pointing (`TRACKING` or `SLEWING`).

showtel_plots.py This part contains the functions to plot the sky position & visibility of the observed sources, and the current pointing of the radio telescope.

showtel_forbidden.py This file includes the functions involved with the monitoring of the pointed sky region by the antenna suffered from RFI phenomena, at the running observing frequency (Sect. 2.6).

showtel_distance.py In this file there is the part regarding the calculation of the angular distances, the management of the ephemerides both of the Sun and the Moon (for further information, see Sect. 2.7), and the management of the time evolution of the position of the observing source.

SHOWTEL contains also two tables, easily editable by the user at any time:

list_receivers.dat This file contains information about the receivers installed at SRT. For each receiver, this table lists the name, the minimum and maximum observing frequency, the critical and the standard threshold (concerning the Sun avoidance).

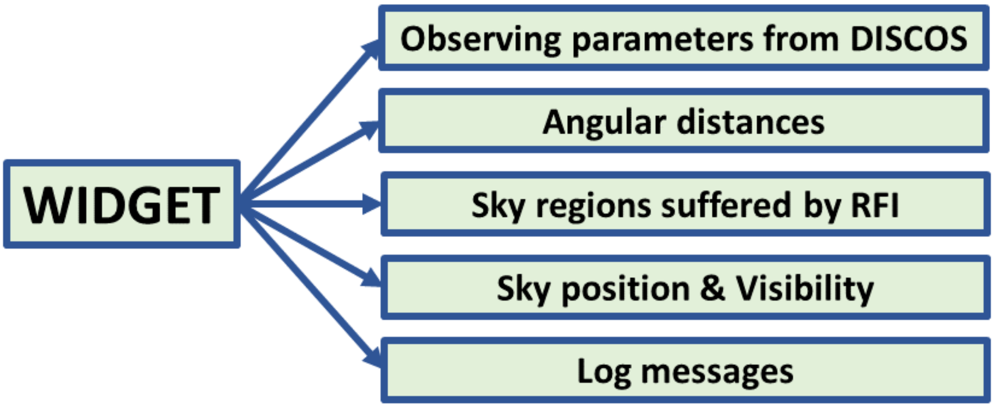

Figure 6: *Structure of the* ShowTel *output. These outputs are deeply described in Sect. 2.*

list_rfi.dat This file includes the information about the RFI sources detected by the RFI group at SRT (minimum and maximum azimuth, minimum and maximum elevation, minimum and maximum observing frequency, RFI origin, presence of RFI spectrum).

5 Output of ShowTel

As shown in the diagram of Fig. 6, all the output produced by ShowTel is contained in the widget, deeply described in Sect. 2. In particular, the output includes:

- all the observing parameters obtained asking every N seconds (default value: $N = 5$ s) this information at the DISCOS antenna control system;
- the angular distances (in units of degrees) Sun-radio telescope, Sun-astrophysical source, Moon-radio telescope, Moon-astrophysical source;
- the sky regions suffered by RFI at the running observing frequency;
- the sky position & visibility of several sources (Sun, Moon, source) – with their trajectories – and the pointing of the radio telescope in real-time;
- log messages.

6 Releases

First release (test - widget containing only the switch on-off button of DISCOS):
ShowTel *0.1* developed under Python 3.10.11 on Ubuntu 22.04 (June 2023).

Second release (widget without the log panel):
ShowTel *0.2* developed under Python 3.10.14 on Ubuntu 22.04 (March 2024).

Third release (widget with the log panel, as shown in Fig. 1):
ShowTel *0.3* developed under Python 3.11.7 on Ubuntu 24.04 (June 2024).

7 Remarks

The ShowTel user has to take into account the following:

- ShowTel usage is intended for observations with the antennas in the INAF network.
- For all the questions related to using ShowTel and its license please visit the relative GitHub developer platform.

8 Curiosities

The name ShowTel comes from the name of a similar application used at the Parkes Observatory[19] for displaying the telescope status (only).

9 Future development of ShowTel

Code optimisation and improvement will make ShowTel an even more complete tool, such as the implementation of direct pointings of the antenna by a simple click in a point of the sky plot in the Sky position & Visibility panel, and the improvement of the connection between ShowTel and DISCOS control system. In the next release of ShowTel we hope to add other information in the widget, such as (1) the project code, (2) the azimuth sector, (3) the schedule name with the number of the running scan/sub-scan), and (4) the set/rise time of the source. In a further release of ShowTel we need to implement a warning system for when (1) the source is close to the upper elevation limit of the radio telescope, and (2) the pointing is close to the telescope technical azimuth limits. Moreover, we will improve the panels in NO SOLAR operation (Fig. 4, on the left) using a planisphere-like geometry (e.g. Hammer projection).

Shortly, ShowTel will also be used in the Solaris project, especially to implement the pointing test on the receivers: the observation of the calibrators – with known position – allows to check if the commanded pointing (by the encoders) is the same as the effective one, improving the pointing system of the receivers. Last but not least, this Python package will also be suitable for the new receivers up to 116 GHz, soon operating at SRT (and in the near future also at Grueff and Noto) within the PON project. These improvements are crucial for a future complete sharing of ShowTel with the international community; for further information and collaboration, the reader is encouraged to contact the authors of this technical note.

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[19] https://www.parkes.atnf.csiro.au/

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Table 1: *List of Python libraries needed to use* SHOWTEL.

Python Library	Minimum Version	Use
astropy	6	Science
numpy	1.26	Science
pillow	9	Imaging
matplotlib	3.8	Plots
pytz	2024.1	Time
astroquery	0.4.7	Ephemeris
skyfield	1.45	Ephemeris
tk	8	Widget & Graphics
tkmacosx	0.1.6	Widget & Graphics
pydub	0.25	Audio
gtts	2.5	Audio

A ShowTel: System Requirements

ShowTel is compatible with the following characteristics:

- at least Ubuntu 20.04 (64-bit PC desktop image), or macOS High Sierra 10.13.6, or Red Hat Enterprise Linux 8; GNU/Linux environment can also be installed in the Windows Subsystem for Linux (WSL) directly on Windows, without the overhead of a traditional virtual machine or dual-boot setup[20];
- at least 8 GB RAM (16 GB recommended);
- at least 1 GB of free disk space (necessary for both the installation and the cache handling);
- Python 3.10.X or higher.

B Download and installation of ShowTel

ShowTel is ready to be used once placed in the user's preferred folder, but it needs only the installation of the Python libraries necessary to make it work (see Table 1). To prevent any possible system conflicts, it is strongly recommended to manage the Python environment and its libraries through a free and open-source system installer, such as Anaconda[21], Miniconda[22], or pyenv[23]. For the case of Anaconda (or Miniconda), a useful guide to the installation procedure is available in [10]. Another solution to build, share, and run ShowTel efficiently is the creation of a container, thanks to Docker[24] or other similar applications; this option is under development.

Before using ShowTel for the first time, the user has to insert the correct IP address and number port of the Socket connection with Discos in the file `showtel_connection.py`, contained in the sub-directory `utilities`. After this Socket setup, the user has to (i) open

[20] https://docs.microsoft.com/en-us/windows/wsl/
[21] https://www.anaconda.com/products/individual
[22] https://docs.conda.io/en/latest/miniconda.html
[23] https://github.com/pyenv/pyenv
[24] https://www.docker.com

a terminal window in the directory where ShowTel is placed, and (ii) choose between two alternative approaches:

1. type the command `python showtel.py`;
2. type `run showtel.py` in the `ipython` environment.

As mentioned above, since ShowTel requires some Python libraries, the user must check their presence and, if necessary, install the missing ones. Once these libraries are installed, the user can type again `python showtel.py` (or `run showtel.py` in the `ipython` environment); in case of successful installation of these libraries, an intuitive widget appears (Fig. 1), and the user can start the real-time monitoring of the observations.

ShowTel is an open-source Python package, available in the GitHub developer platform. This Python package is in the installation phase in the "Pulsar/VLBI" computer in the control room of SRT, and it will soon be available for the observers.