SRT Dynamic Scheduling - Observation Control Tool - first deployment and general overview

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Abstract

In this report we present a first look at the OCT, that is a foundational software component of the new SRT Dynamic Scheduling system, currently under development. We give a brief description of the overall architecture of the SRT-DS, which is designed to exploit the new high-frequency capabilities of SRT. We therefore provide a description of the technologies used to implement the software layer on which OCT is based. The OCT is designed to be compatible with the most popular browsers. In the current configuration, the web access is restricted to a VPN protected server, however we intend to expose the service as a portal with public access. We give a detailed description of the OCT layout, to provide the user with the basic knowledge to interact with the tool's features. The general overview provided here will allow you to access OCT and use the web tool to prepare your observations.

1 Introduction

In 2018, through the project "Enhancement of the Sardinia Radio Telescope for the study of the Universe at high radio frequencies" (PON-SRT), the Sardinia Radio Telescope has been significantly improved, thanks in large part to the acquisition and development of new state-of-the-art receivers. Thanks to the PON-SRT upgrade, the telescope is now capable of observing across the entire frequency range from 0.3 GHz to 116 GHz for which it was originally designed. Such potential requires proper leverage, in order to minimize the loss of scientific time. In fact, mostly with high-frequency observations (K-band and upper), the weather conditions fill a crucial role, since conditions like the atmosphere opacity, the wind, the humidity, (and so the rain), the cloud coverage and others can impact significantly the possibility of observing. The goal of the Dynamic Scheduling is to correctly assign observing slots under the right weather conditions, the same ones for which the PIs in the original proposal calculated the exposure times needed to achieve their science goals [1]. However, weather forecasting is only one of many requirements. In fact, Dynamic Planning implies a thorough review of the entire observational model used so far at the SRT. For this reason, in 2023, the INAF scientific directorate, as part of the UTGII activities, created working group WG-F01-11, with the aim of studying and defining the requirements of a complete dynamic scheduling system for the upgraded SRT. The group worked for approximately a year. They examined the main scheduling systems of other radio facilities, the current SRT operating model, and static scheduling procedures. They recognized the need for a more dynamic scheduling approach in light of the recent high-frequency upgrade. Finally, the group produced a detailed report describing a complete DSS for the SRT, defining its architecture, key requirements, and a road map for its implementation. From now on, we will refer to this architecture as the SRT Dynamic Scheduling System (SRT-DS).
Within the SRT Dynamic Scheduling of SRT telescope observations a Web Portal is in charge of interacting with the several actors of the Observational process:

- Principal Investigator (Scientist)
- Co-Investigators (Scientist)
- Time Allocation Committee Members

[1] a primary report about the Dynamic scheduling can be found here [2] (Buffa et al., 2017)

- Observations Scheduler
- Telescope Operator
- Telescope Officer (Responsible of Operations)
- Director
- Anyone who is involved in the scheduling process

The basic system architecture is displayed below:

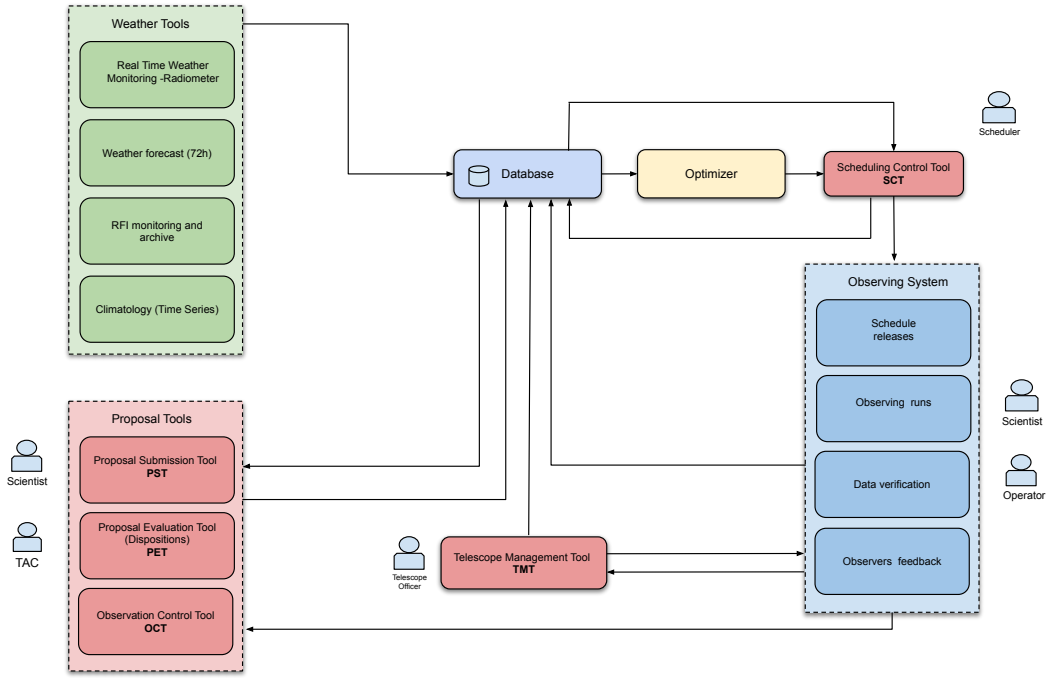

Figure 1: System architecture

The purpose of each component is briefly explained below:

- Optimizer : the core of the system, a set of algorithms whose purpose is to verify observation information (stored in the database) and, after some optimization, release two new schedules: a short term 72-hours schedule and a long term schedule. A full overview can be found here [3]
- Database : the main and central storage of all the data that are created, read and used by the whole Dynamic scheduling system. Each component is designed to directly (or indirectly) interact with the database, performing operations on it, in order to bring the system closer to real-time operation
- Proposal Tools : The set of tools for managing the initial observation lifecycle, when observation proposals are prepared and submitted to TAC for approval. Two different tools will be involved:
  - Proposal Submission Tool : currently a working and widely used Proposal Submission Tool already exists, although this is not integrated with the SRT-DS system nor with the DB at all, obviously. Since there will be the need to take care of the whole proposal's life, a strong rework (or a rewrite) of this tool will be performed. The purpose is to allow the PI to submit the observation proposals, providing an easy interface to input all the information useful to the TAC, in order to evaluate and grade the submissions

  - Proposal Evaluation Tool : The web interface for evaluating each observation proposal. It is used by the TAC organizational structure and generates elements called Projects, which will be managed by PI via OCT

- Observation Control Tool : This component, fundamental to observation lifecycle management, manages the core of the lifecycle, from the time approval phase to the actual scheduling of the observation block. Through this tool, the user can completely create and manipulate the time allocated by the TAC, breaking it down into atomic elements called Observing Block. The OB represents a single observation and is scheduled by the optimizer

- Weather Tools : the collection of all the software related to the weather forecast and monitoring. Critical to short-term (and even long-term) planning, the Weather Tools module integrates the existing repository and utility system with the entire SRT-DS system, piping data into the main SRT-DS database. Communication between WT and SRT-DS will be handled by middleware, most likely

- Scheduling Control Tool : This is the part of SRT-DS responsible for managing the schedules produced by the Optimizer. The Scheduler is the user responsible for interacting with SCT and is responsible for approving, modifying, and validating schedules

- Telescope Management Tool : a web tool used primarily by the telescope operator (RDO), tasked with exposing the current state of the telescope to the system, updating the DB with information about the hardware and software status, operator availability, and even the availability calendar

- Observing System : This is not a specific part of the SRT-DS software, but rather an integration between the current astronomical observation pipeline and the future SRT Dynamic Scheduling suite, meaning that the program release, observation execution, data verification, and observer feedback phases will be largely supported by the new system. Many interactions with other components can occur during the observation phases, such as verification of the actually observed OB (OCT) and feedback on the observed OB (OCT)

For a deep knowledge about the Dynamic scheduling system design and architecture, see [4] and the unpublished [1].

The purpose of this document is to provide as complete a guide as possible on the SRT-DS software developed so far, with particular attention to the OCT tool.

2 Technology stack

The application was built primarily using these software components:

- Back-end : Django framework v 5.3 [2]

- Front-end : Javascript (evolving to Typescript) on HTML-SASS-templates, with the integration of some React.js components [3]

- Database: PostgreSql [4]

- Source code: tuned under a Git repository hosted in the INAF GitLab, currently private and accessible only by the Dynamic scheduling group members. The source code will be treated with respect to the INAF policy

Django is a free and open source framework, focused on the back-end web development. The key concepts about Django are **speed-development**, **scalability** and **security**, basic in a complex system like the SRT-DS. The web development has taken a sudden turn in the last decade, with the advent of a series of very powerful frameworks (mostly JS-based), featuring unique front-end and back-end integration, and characterized by a relatively steep learning curve. Django is structured in a such way that it mostly takes care of the backend side, totally delegating the user interaction phase to some

[2] https://www.djangoproject.com/
[3] https://react.dev/
[4] https://www.postgresql.org/

other actors, either the basic HTML templates with necessary enrichment, or some modern framework like React.js or Next.js. The key-role, in this regard, is played by the Django-REST framework middleware, that allows the back-end to communicate with any kind of front-end capable to use the exposed APIs.
Being a project in continuous evolution, the SRT-DS requires a high level of scalability, feature guaranteed by Django through a strong separation of layers and a robust cache management. Moreover, a system like the SRT-DS must ensure an high level of security, of course, and Django numerous tips and tricks to maximize the ease of implementing web security best practices. Naturally, the product is now highly maintained and used by thousands of developers, that still populate an high and active community. And for a web product this is essential. These are the reasons why Django was chosen for the development of the SRT Dynamic Scheduling (SRT-DS) project.
The core of the project, as mentioned, is the Optimizer component, that can guarantee a great improvement on the observation scheduling, hopping from a static to a dynamic operating mode. However, the designed system covers a wide set of sides regarding the observation process, offering substantially a complete system to automatize the process, from proposal to final feedback. Thus, the front-end takes on considerable importance, and therefore, great attention was paid to the user experience phase from the very beginning of development.
The classical Bootstrap framework [5] is a cornerstone of the UI. In addition to Bootstrap, Django templates have been widely used (HTML files with Django specific rendering tags), and some module has been developed through React.js, a modern framework based entirely on JS.
The front-end logic has been entrusted to Javascript, at the moment. This solution is now adapt to the requirements, since several useful and open source components are written in JS, but it is important to note that, due to some development needs (especially in terms of robustness) a development branch is currently upgrading the code to Typescript. Styling and aesthetic are managed by SASS [6], a cutting-edge kind of extension of the classical CSS style-sheets.
The database technology fell on PostgreSql, an open source relational system based on objects, highly maintained, robust and well suited to the data that are going to be stored into the main DB.

3 Compatibility and requirements

The Web Portal is compatible with all the most used browsers:

- Google Chrome
- Firefox
- Brave

About Safari web browser, some issue has been reported and it is currently under investigation.

The compatibility with the not supported or deprecated browsers (e.g. Internet Explorer) is not guaranteed, since a wide usage of Javascript (and in future TS) APIs is performed.

4 Web portal description

Currently the Web Portal is hosted at an INAF server, reachable only through the VPN layer.

The host is deployed at the location **http://192.168.140.42/**

The following sections aim to provide a complete overview of the state-of-art of the SRT-DS developed features, namely:

- Full layout
- User management, user authentication and user register
- Observation Control Tool
- Calendar

[5] https://getbootstrap.com/
[6] https://sass-lang.com/

4.1 Login layout

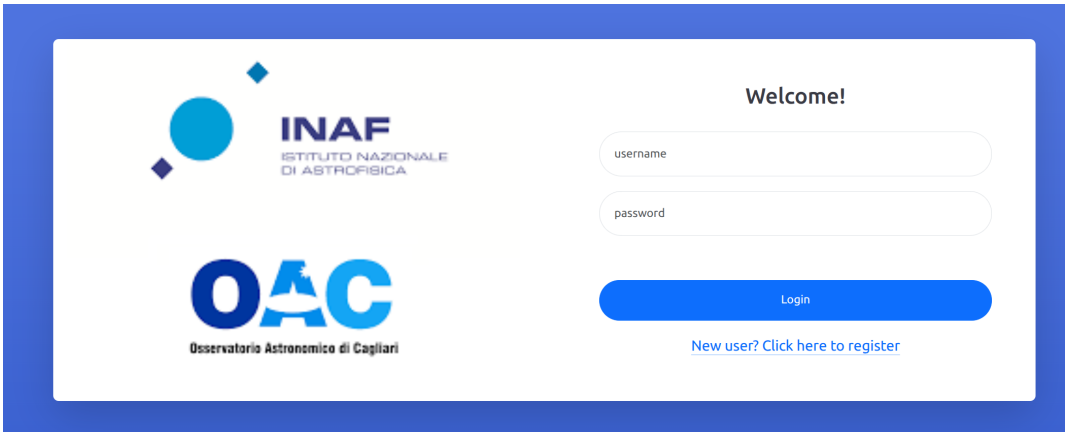

Figure 2: Login layout of the DS Web Portal

The login screen allows to authenticate the already registered user into the system. Currently, the authentication leverages solely on the Django builtin system, but leaning toward the INAF LDAP authentication is going to be fully adopted, for the internal users. Non-INAF users will also be authenticated via the basic system.

The link below redirects to the register form.

4.2 Registration layout

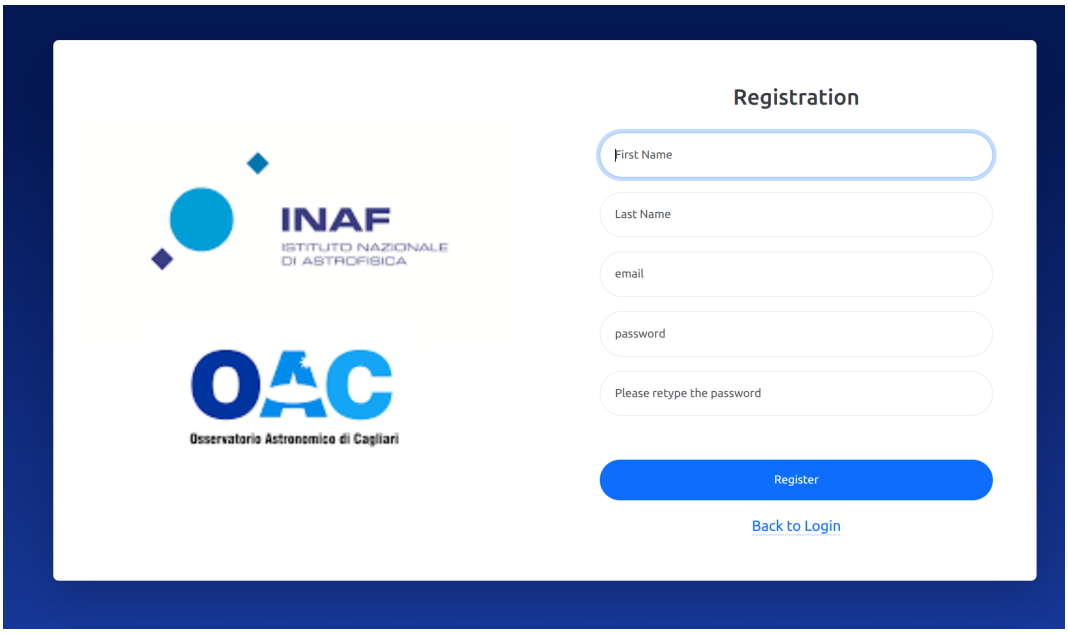

Figure 3: Register layout of the DS Web Portal

New users must register using this form. All fields are required:

- First name
- Last name
- Email

- Password (+ retype check)

As of this writing the SRT-DS is in the Alpha-test stage [7], therefore the users will be automatically registered as Investigator (either PI or co-I). In any case, an internal role management system exists that discriminates the visibility of elements. Users should be able to register with one (or more) of the following roles:

- Investigator
- TAC
- RDO
- Director
- Scheduler
- Operator
- Admin

Once fully operational, the system will default the role "Investigator", the system administrator will most likely adjust the role later. A role assignment policy is currently being developed.

4.3 Main layout

The landing page is basically structured with a side navigation bar and a header, with the content inside.

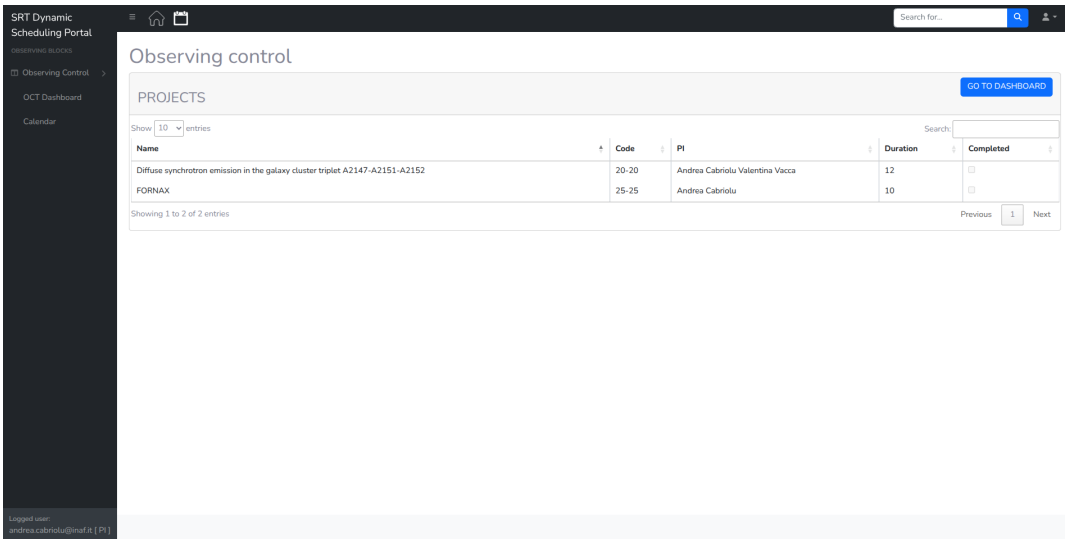

Figure 4: Main layout of the SRT-DS Web Portal

[7] a phase in which the software is still in development state and not all the features are implemented yet

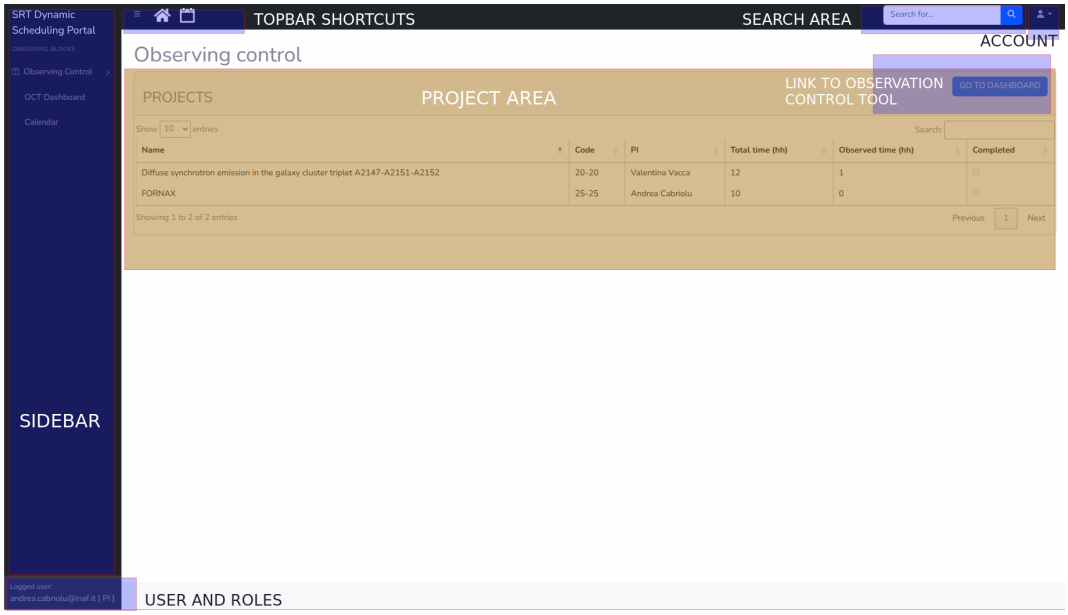

Figure 5: Annotated landing page

As mentioned in 4.2, it's remarkable to emphasize again that **each section of the Web Portal can be visible to a selected user or group, based on the assigned roles**. E.g., the TAC members would be able to view the PET section, while the Investigators would not.

4.4 Top bar

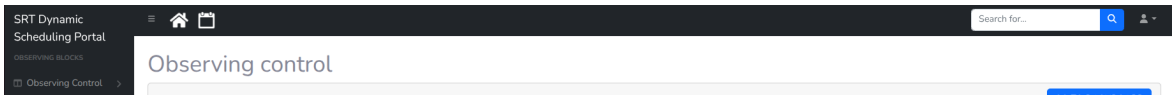

Figure 6: Top bar with expanded sidebar

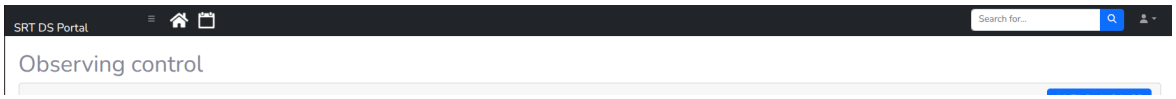

Figure 7: Top bar with minimized sidebar

The top of the navigation bar hosts some shortcut and utility:

- The **3 horizontal small lines** hide and show the side bar. The web portal title changes in accordance with the hide or show state of the top bar (see fig.6 and fig.7)
- The **home** icon redirects to the main view, based on the roles (the Investigator will see his project list)
- The **calendar** icon redirects to the calendar manager (see section 5.2)
- The search text box allows a wide search throughout the web portal (**TO BE IMPLEMENTED**)
- The **profile** icon allows to choose between 2 sub items:
  - **About**: general information about the tool
  - **Logout**: logout the user and go to the login page

4.5 Navigation bar

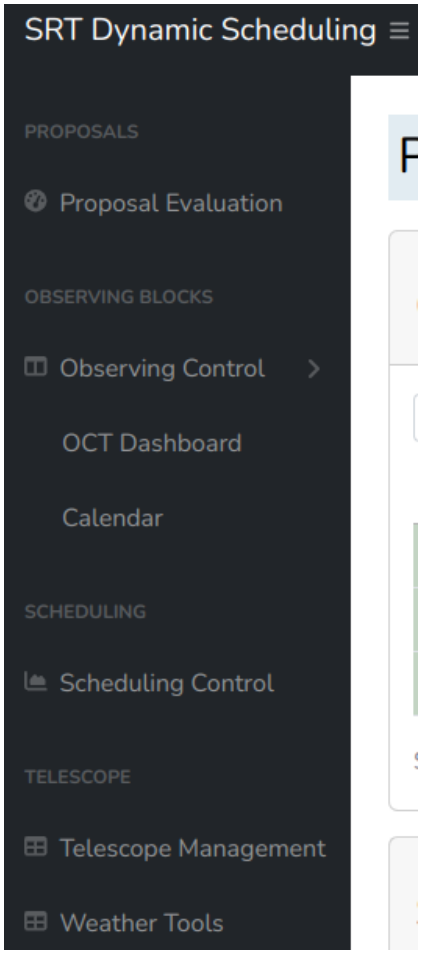

Figure 8: Sidebar

The sidebar is located on the left of the screen. It can be collapsed and expanded through the upper-right button. The collapse-expand command persists along the navigation.

Some elements within the navigation bar can also be collapsed and expanded, such as the Observation control section in the 8 figure. This section opens automatically when you change pages, due to a design choice.

Clicking a link changes the central content of the Web portal layout. Closing the main page with any unsaved changes will prompt you to confirm the browser's assertion.

As reported in figure 4.3, not all the items would be visible, but only those whose visibility is allowed to, depending on the logged user role.

4.6 Proposal management

The table below is owned by the TAC, and is visible only by them. It contains the list of proposals to be evaluated and scored, so that approved **proposals** can be definitively transformed into **projects**.

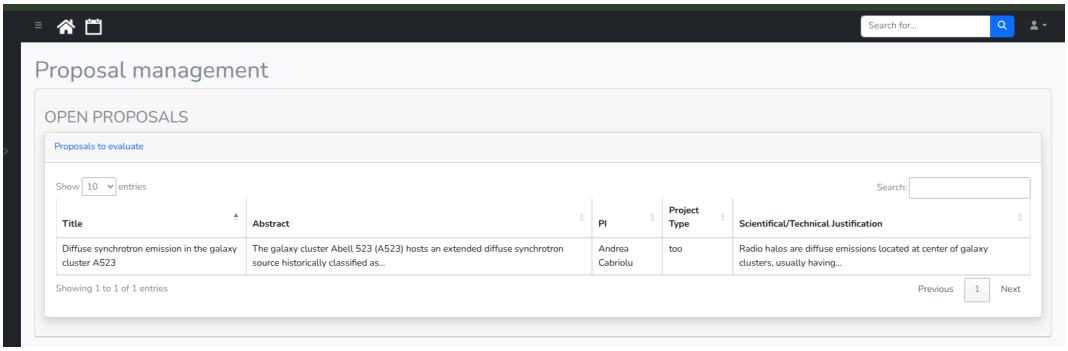

Figure 9: Proposals list

The PET is a tool yet to be developed, this table represents the starting point of it.

5 Software capabilities - deep-dive

5.1 OCT

The OCT is accessible by two main entry-points, as shown in the picture below.

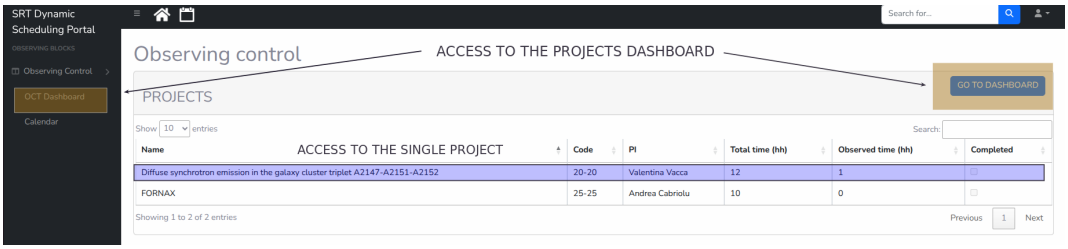

Figure 10: Access to OCT

Clicking the item in the sidebar, or the blue button "Go to the dashboard", leads to the list of projects, split into:

- Active
- Completed

See 5.1.1.

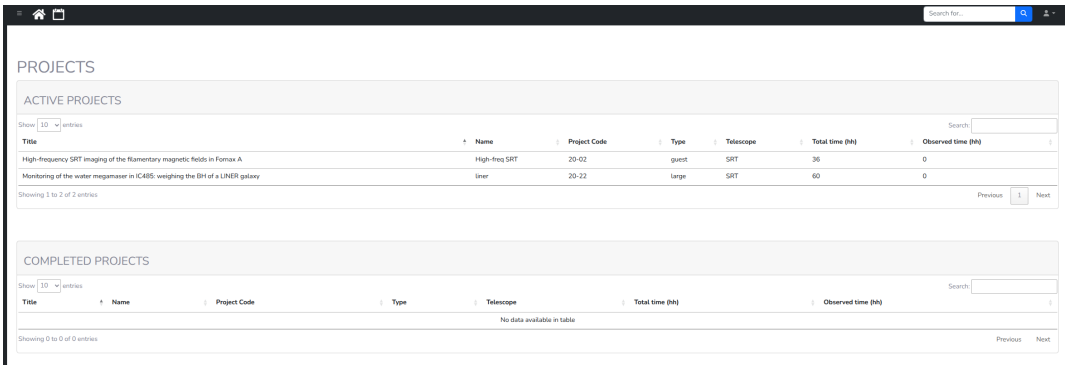

Figure 11: Projects dashboard

Clicking on a table row (single project) takes directly to the project management page (5.1.2).

5.1.1 Projects dashboard

This is the section of the Web Portal dedicated to the management of the projects. Once the TAC approves a proposal, this one becomes a project. The main content of the layout displays two tables:

- Active projects
- Completed projects

The items are exposed with a basic set of information:

- Title
- Name
- Project Code
- (Project) Type
- Telescope

- Total time (hh)
- Observed time (hh)

Tables can be sorted through the specific arrows.

Figure 12: Sort arrows

5.1.2 Project detail

The figure below shows the different parts of the section.

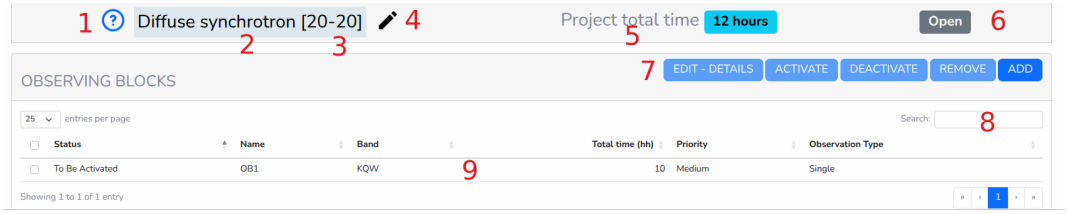

Figure 13: Project detail page (part 1)

1. **Project Title tooltip** (hover this to show the full title)
2. **Project Nickname**: an informal (usually) shorter name for the project
3. **Project Code**: the unique number of the project, composed by ([year-progressive number]
4. **Edit Nickname button**: through it it's possible to edit the project nickname
5. **Project Total time**: it shows the total amount of hours assigned to the project
6. **Project Status**: one of the possible states of the project. Possible states:
   - *Open*: the project is currently open, editable and Observing Blocks can be created
   - *Expired*: the project overcame the current semester limit date. No action is possible on the project
   - *Open - Extended*: the project overcame a previous semester limit date, but it's been extended. It's editable and new OBs can be created
   - *Completed*: all the OB have been completed. Project looks in read-only state.
   - *Canceled*: project canceled. No action possible on project.
7. **Toolbox**: a box of buttons to interact with the below OB grid:
   - *Edit - Details* button: if only ONE item of the Observing block table is selected, it takes to the Observing block full detail page. If more than one item is selected, the button is disabled (see 5.1.6). **Warning**: double click on a row redirects to OB details too
   - *Activate* button: it activates a selection (one or more) of Observing blocks items. Activated OB rows look green in color
   - *Deactivate* button: it deactivates a selection (one or more) of Observing blocks items
   - *Remove* button: it removes a selection (one or more) of Observing blocks items
   - *Add* button: it opens a modal window through which it's possible to fill a minimal set of information to create a new Observing Block (see 5.1.5)

8. **Search** button : it performs a smart research inside the OB table, filtering on ALL the keys. I.e. every character sequence can be searched

9. **Observing Block table** : the list of all the observing block created for the current project, both activated and not yet activated ones. A basic set of columns is exposed here:

   - Status
   - Name
   - Band
   - Total Time
   - Priority
   - Observation Type

   The full list of OB features can be set clicking on button *Show details* (see 5.1.6) or double-clicking a table row.

5.1.3 OB heatmap and metrics

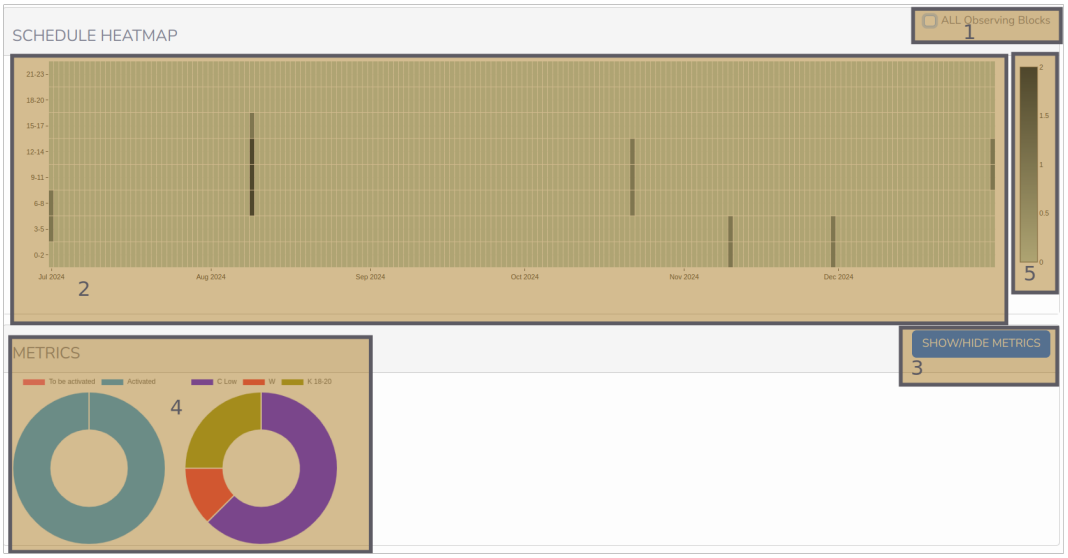

Figure 14: Project detail page (part 1)

Description of the figure above:

1. Switch to show all the observing blocks related to the project, including the not related ones
2. Heatmap showing the distribution of the activated OBs over the current semester. This heatmap is updated by the Optimizer every time an OB receive a schedule date. This chart can be zoomed (see 15)
3. Switch to show or hide the metric charts
4. Metrics: There are currently only two types, but more can be created. The current ones represent:
   - the ratio between activated and not activated OBs
   - the distribution of the activated OBs among the different bands
5. Heatmap color map

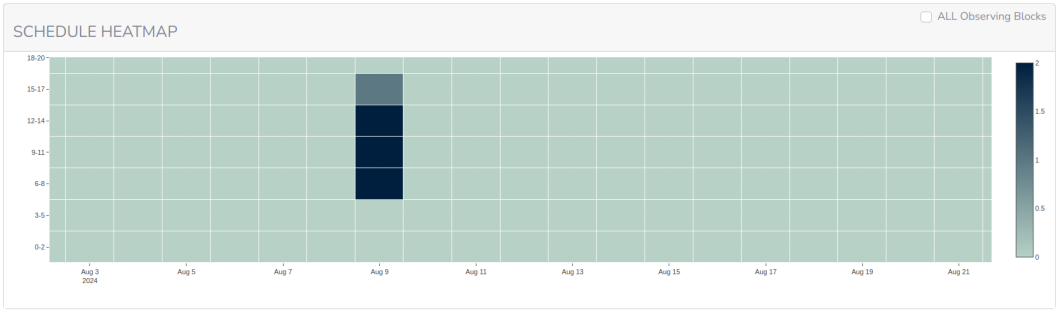

Figure 15: Project detail heatmap (zoom)

Clicking on a single item square (thus, only one single Observing block) the OB detail page is opened. Clicking on a multiple item square (more than one Observing block) a choose page is opened.

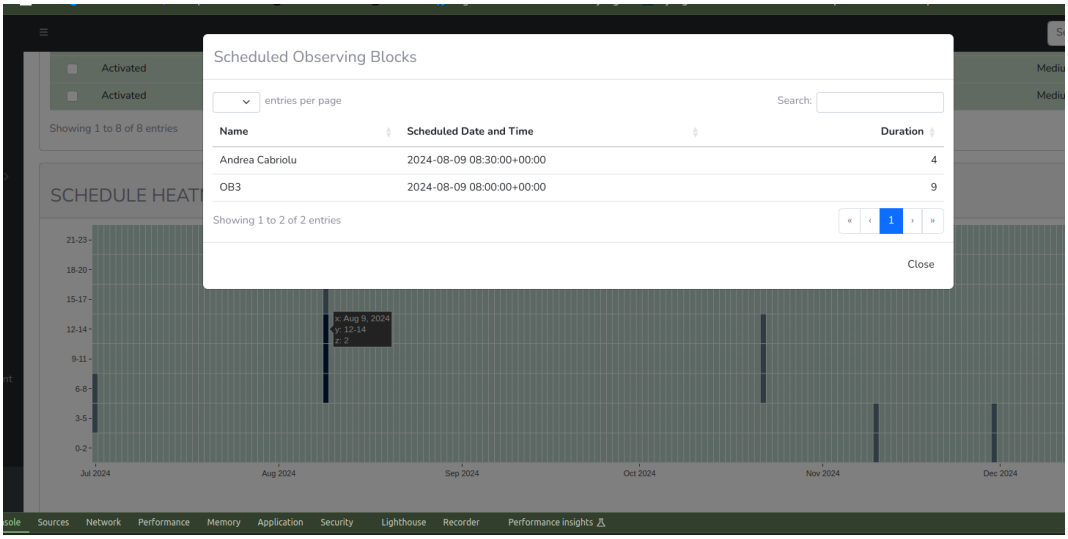

Figure 16: OB choose page

Clicking on a single item will take to the Observing block details page.

5.1.4 Investigators resume

Figure 17: Project detail page (part 3)

1. Details of the current PI for the project
2. Details of the COI of the project

5.1.5 Modal window for creating a new observing block

Clicking the "ADD" button triggers the modal window displayed below:

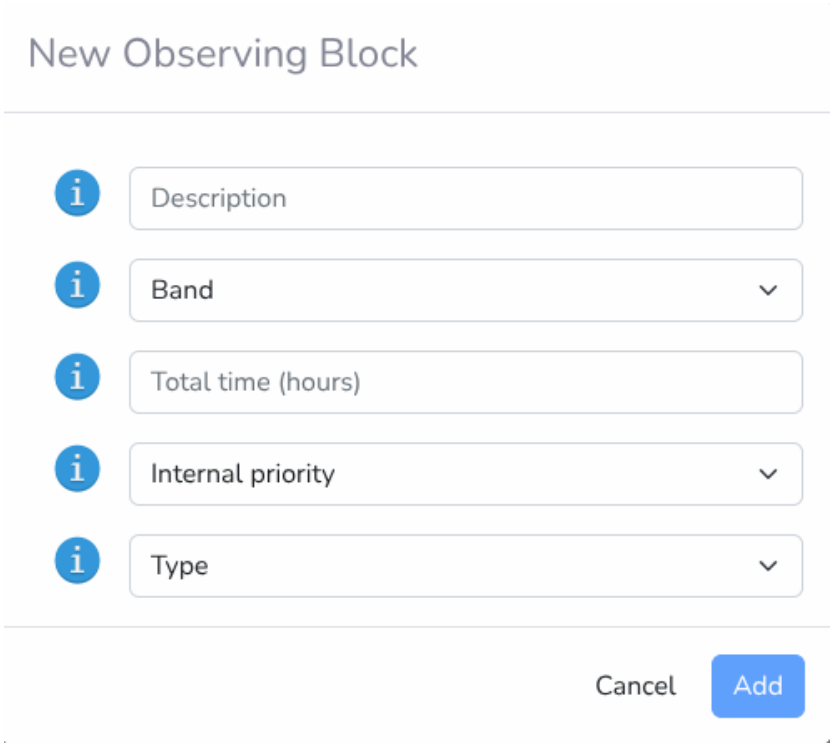

Figure 18: Creation of a new Observing block

5.1.6 Observing block details

All the parts of the Observing block details page (19) are described here:

1. Back to the project details page
2. If some editable item has been edited this button allows to save the changes and go back to the project details page
3. Observing Block basic attributes. The Status attribute cannot be edited. The Mode selector allows to select, among the others, the "Maintenance" mode, which opens a subset selection that regroups all the possible technical tasks to be done at the antenna. "Show/hide advanced details" button opens a window to edit 4 more attributes (20).
4. Observing Block weather section. The weather class is calculated and read-only, the other attributes can be changed. "Show/hide weather info" button opens a window to show (read-only) the weather conditions that will be taken as target when the Optimizer will try to schedule the OB (21)
5. Scheduling section. Internal priority, LST Range and Periodicity can be set here
6. Dates range table. Through this table one or more optional date ranges can be added to the OB, to give a more precise constraint to the Optimizer
7. Button to add a Dates Range
8. Button to edit a single row
9. Button to remove a single row

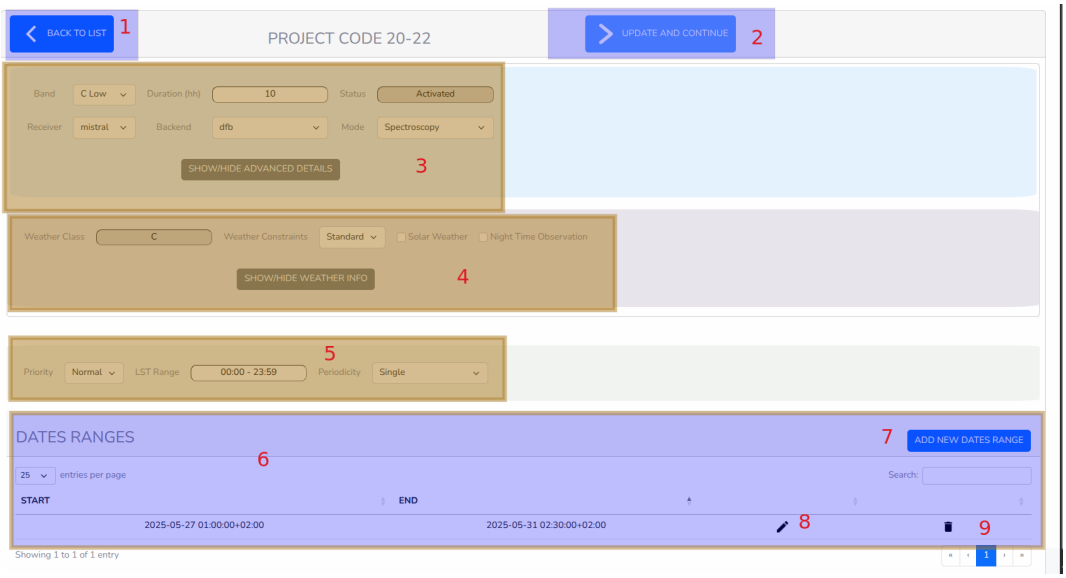

Figure 19: Observation block details

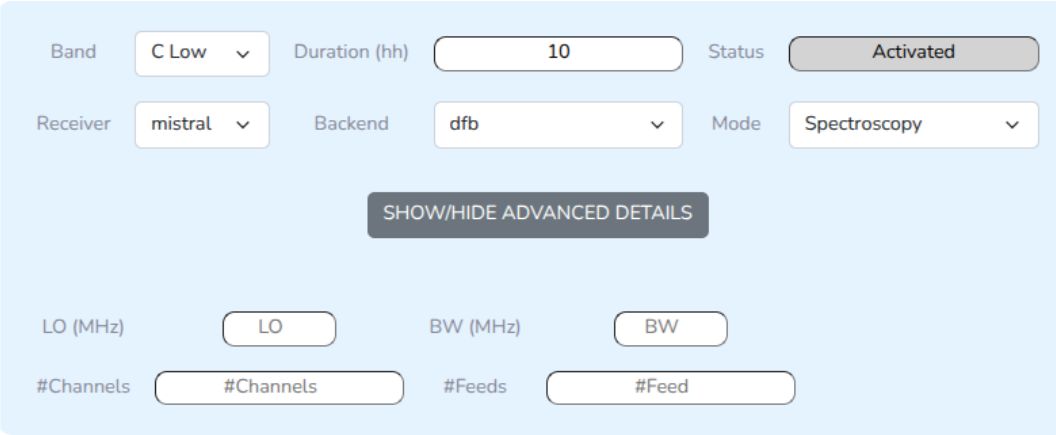

Figure 20: Observation block details - advanced details

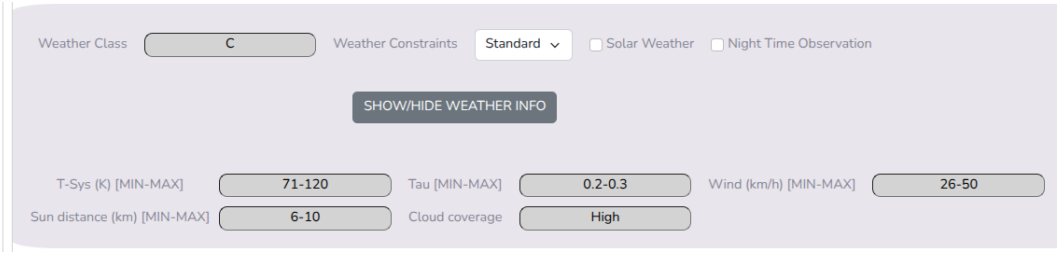

Figure 21: Observation block details - weather advanced details

5.2 Calendar

The second item under the Observing Control area, in the sidebar, is the **Calendar**.
This is an interactive tool that allows you to perform various time management actions throughout the semesters and also displays a variety of information, such as the activation status of OB. The Calendar tool is also accessible, for authorized users, via the dedicated icon button in the top bar.

The purpose of this tool is fundamental: it will likely be the most frequently consulted section of the system. In fact, every type of event related to scheduled observations will be displayed in the Calendar, allowing the user to check, edit, delete, and automatically organize their observation time, according to the dates automatically scheduled by OB. Furthermore, a very important feature is the visibility of team activities, as the calendar can be filtered at the project level, meaning that both PI and COI events will be displayed together, giving users the opportunity to see the status of the team's availability. This allows PI to obtain a high-level overview and avoid lengthy and distracting communications with the team. Notifications (via email) will be handled automatically by the SRT-DS system; this feature will be explored in more detail in a further technical report.

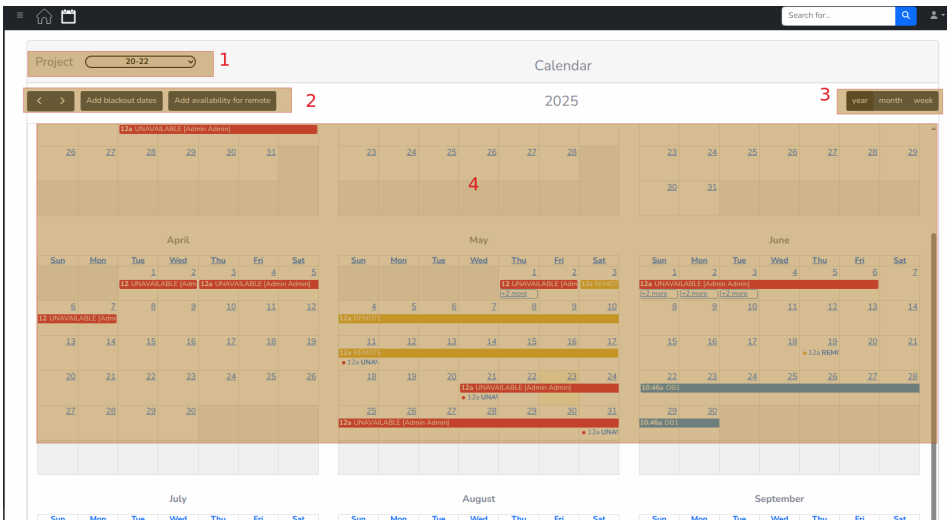

Figure 22: Calendar - landing page

A description of the main parts of the calendar follows:

1. Select the project in which the user is involved as PI or Co-I
2. Toolbar
   - The left couple of arrows allows to shift the time period (year, month, week)
   - Add blackout dates: it opens a modal window to add own unavailability days. These will be the dates claimed as available for the observations, and the Optimizer will keep them in count for its calculations (26)
   - Add availability for remote: it opens a modal window to set own availability days for remote observations (26)

3. Change calendar view, between:

    - Year view
    - Month view
    - Week view

    See 23, 24, 25.

4. Interactive area, the events are shown in this space. Red events are the blackout dates, yellow events are the remote dates, blue events are the scheduled observing blocks. It is important to state that, indeed, the blackout and remote dates are date-times, since an investigator is free to choice the time granularity with the precision of 1 hour

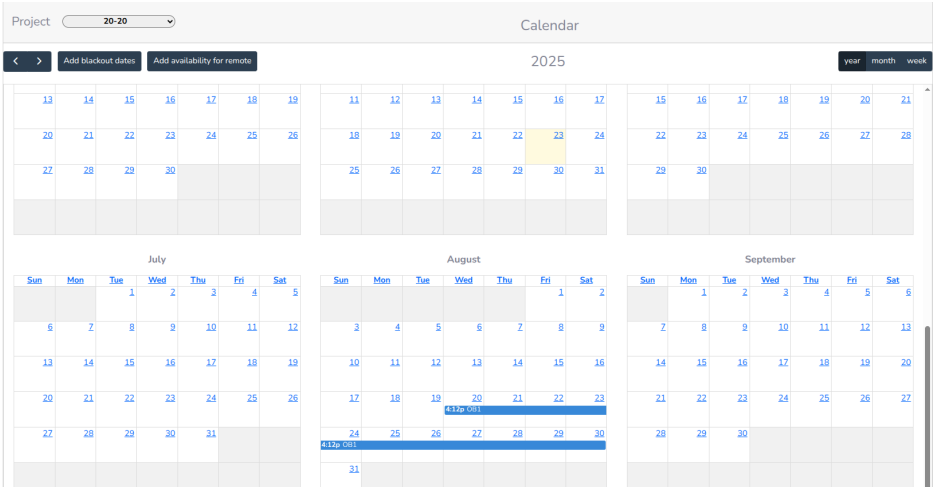

Figure 23: Calendar - year view

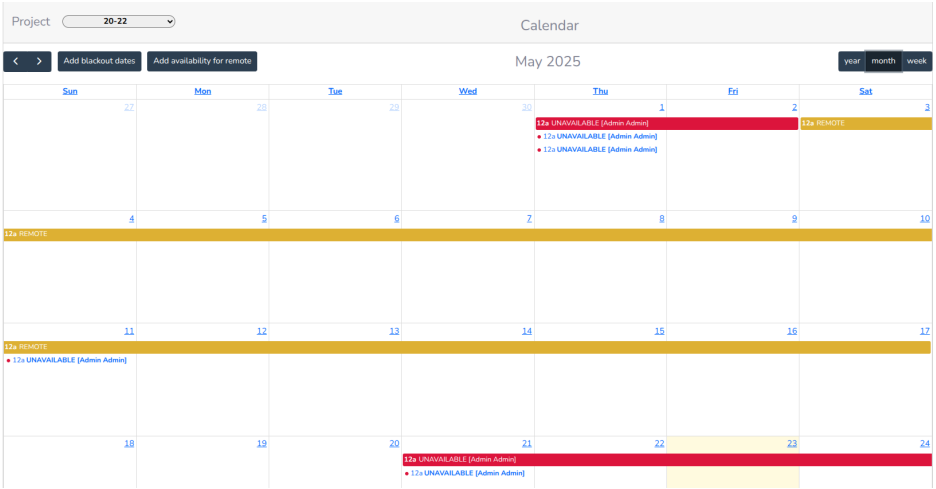

Figure 24: Calendar - month view

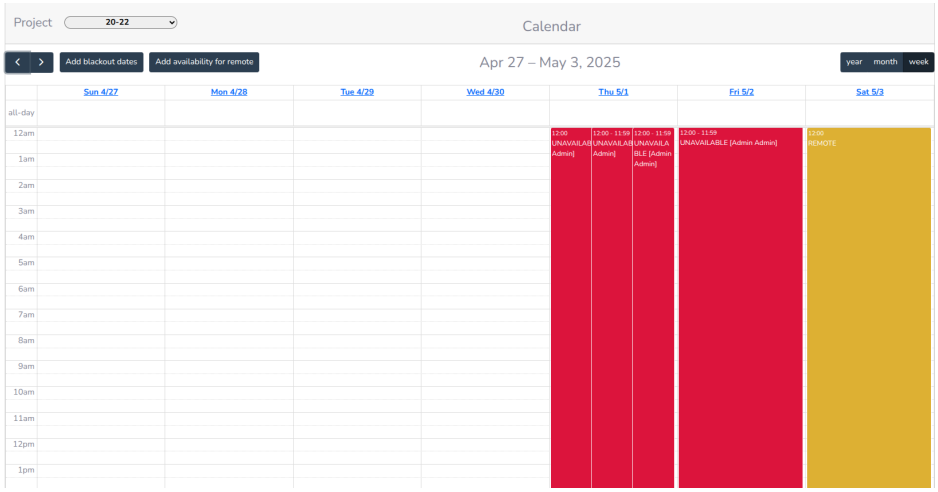

Figure 25: Calendar - week view

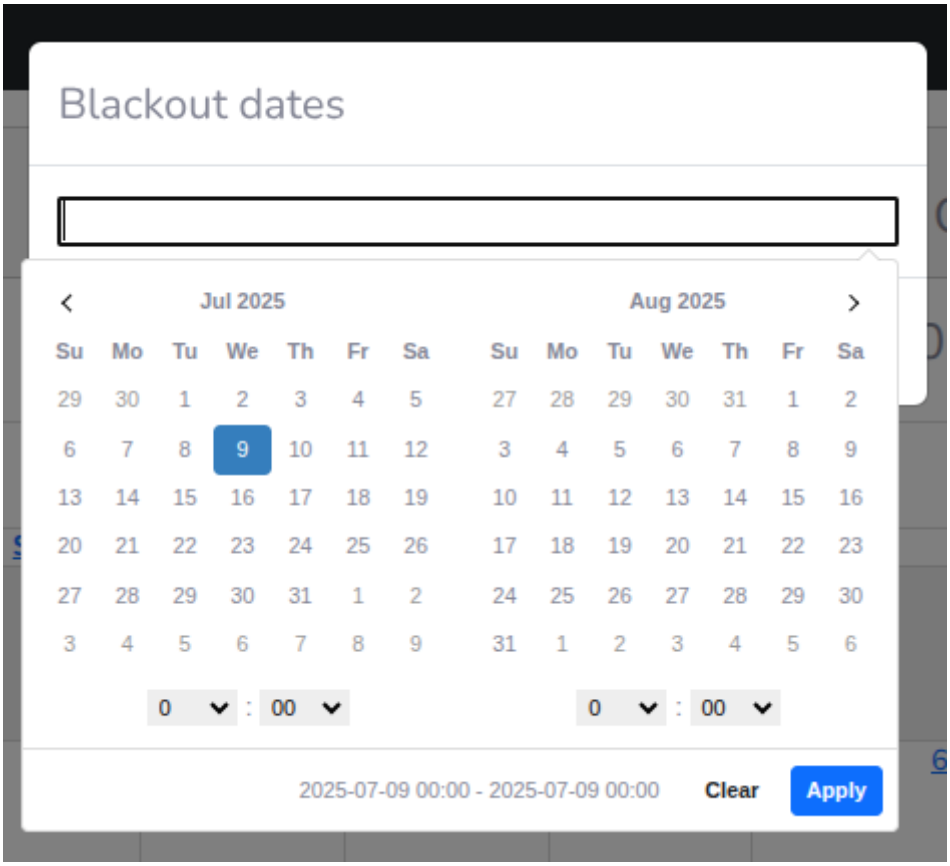

Figure 26: Calendar - Modal for dates selection

6 Conclusions

SRT Dynamic Scheduling is a project under development, intended to become the new, single automatic system responsible for managing the life-cycle of astronomical observations performed through SRT, even though an extension to the existing Italian radio-telescopes is expected. This document was not intended to be an exhaustive technical description of the developed software, for that very purpose another technical report will be prepared, with an in-depth description of each implemented technical solution. It is instead intended to be the main guideline for beta-testers and for the real users who will be involved in the initial launch of the dynamic scheduling system, expected soon, with one of the next observation calls.
The driver of the actual testing phase is the implementation of the Optimizer algorithm, already designed and currently underway. However, as new components are developed, the manual will be updated and kept current.
Currently the pillars have been built (database, layout structure, OCT, calendar). Based on these, the rest of development will be addressed in a faster way, with respect to the user requirements, of course.

Acronyms

COI Co-Investigator. 14, 17

CSS Cascading Style Sheets. 5

DB Database. 3–5

DS Dynamic Scheduling. 2

DSS Dynamic Scheduling System. 2

JS Javascript. 4, 5

OB Observing Block. 4, 13, 14, 17

OBS Observing System. 4

OCT Observation Control Tool. 2, 4, 5, 11, 20

PET Proposal Evaluation Tool. 4, 8, 10

PI Principal Investigator. 2–4, 14, 17

PST Proposal Submission Tool. 3

PT Proposal Tools. 3

RDO Responsible of Operations. 3, 4, 7

SASS Syntactically Awesome StyleSheets. 5

SCT Scheduling Control Tool. 4

SRT Sardinia Radio Telescope. 2, 20

SRT-DS SRT Dynamic Scheduling. 2–5, 7, 17, 20

SRT-DS SRT Dynamic Scheduling System. 2

TAC Time Allocation Committee. 2–4, 7–9

TMT Telescope Management Tool. 4

TS Typescript. 4, 5

UI User Interface. 5

WT Weather Tools. 4

References

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