BinarAlt

Visibility and Observation Planner

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1. Introduction

BinarAlt is the graphical observation planner of the `obs` module of PANORAMA. It was designed for spectroscopic campaigns of (massive) stars, where a night combines many targets with different exposure needs, and where periodic systems (e.g. eclipsing and spectroscopic binaries) must often be observed at specific orbital phases. Its name comes from *binary* + *altitude*: the classic altitude-versus-time chart extended with tools to plan and follow binary systems.

The tool covers three stages of an observing night:

- **Before the night.** Enter the targets by hand or from a CSV file, plot their altitude curves, and let the scheduler place the exposures of each target. The scheduler first secures the highest-priority targets, then fits as many targets as possible, and finally places each of them as high in the sky as it can (Sect. 7).
- **During the night.** Mark each target as *Observing* when its exposures start and as *Observed* when they end. BinarAlt records the real times, the median seeing sampled during the observation, the mean airmass and, for periodic objects, the phase range covered. Weather and Moon distance are monitored: a message is written in the *Log* whenever a limit is crossed, the boxes of the plan and the timelines take the color of the weather alert, and an alarm sounds when a weather limit reaches the red level.
- **After the night.** The *Logbook* is saved to a session file together with the targets and settings, and can be reopened later in any browser.

BinarAlt uses the same astronomical definitions as the Python functions of `panorama.obs` (e.g. `night_info`, `visibility`, `obs_phase` or `periodic_event`), so the times and phases it shows agree with them to a few seconds. Section 4 explains these definitions and the few differences that remain.

What you need

- PANORAMA installed in your Python environment. BinarAlt needs no extra Python package: the local server uses only the Python standard library.
- A modern web browser (Chrome, Edge, Firefox or Safari) with JavaScript enabled. All the astronomical calculations run **inside the browser**, with the Astronomy Engine library bundled in the page, so they also work offline.
- Internet access only for the live weather panel and the web fonts (without internet, system fonts are used).

2. Quick Start

1. **Launch BinarAlt** from Python (Sect. 2.1):

```
import panorama
panorama.binaralt(block=True)   # Ctrl+C in the terminal stops the server
```

2. **Choose the night and the site.** In *Night & Observatory*, set the *Date (night starting)*, i.e. the date on which the night *starts*, and the *Observatory* (e.g. ORM).
3. **Check the scheduler settings.** In *Scheduler*, keep 30° minimum altitude and 10 s overhead per exposure, or adapt them to your instrument.
4. **Load the targets.** Click *Import CSV* and choose a target list, e.g. the demo file `Demos/data_and_results/obs/data/northcircumpolar_targets.csv`.
5. **Plot the night.** Click *Plot Targets*. The visibility plot shows the altitude of each target from sunset to sunrise, the twilights and the Moon.
6. **Plan the night.** Click *Plan Observation*. The planned blocks appear as thick segments on the curves, as bars in the *Exposure Timeline* and as rows in the *Observation Plan*.
7. **Read the Log.** *Log* says how many targets were scheduled and why the others were left out.
8. **Adjust and re-plan.** Change priorities, exposure times or limits and click *Plan Observation* again.
9. **Save the session** with *Save session*.
10. **During the night**, open the *Logbook* tab and click the *Observed* button of each target when its exposures start and again when they end.

> **Tip.** The page saves its state in the browser after every action and restores it when it is reopened. *Clear All* is the only way to start from scratch.

2.1. Launching BinarAlt

`panorama.binaralt()` serves the interface (`binaralt.html`) on `127.0.0.1`, on a free port chosen by the operating system, and opens it in a new tab of the default web browser. The local server also relays the weather requests to the observatory websites, which do not accept direct requests from a web page.

Call	Behavior
`binaralt(block=True)`	The server runs in the foreground until `Ctrl+C`. Use it in scripts (`python my_script.py`).
`binaralt(block=False)`	The server runs in a background thread and stops when the Python session ends. Use it in the Python console, IPython or a local Jupyter notebook, which stay free meanwhile. Default.

- The interface always opens in a separate browser tab, never inline in the console or in a notebook cell.
- The server only listens on `127.0.0.1`, so the page is only reachable from the same computer. From a remote Jupyter server (JupyterHub, Google Colab, SSH) it does not work unless the port is forwarded.
- If the browser does not open, copy the address printed in the terminal into the browser.
- `binaralt.html` is self-contained and can also be opened directly in a browser or published as a web page. Everything works except the weather panel, which then shows that live weather is only available when BinarAlt is launched from PANORAMA.

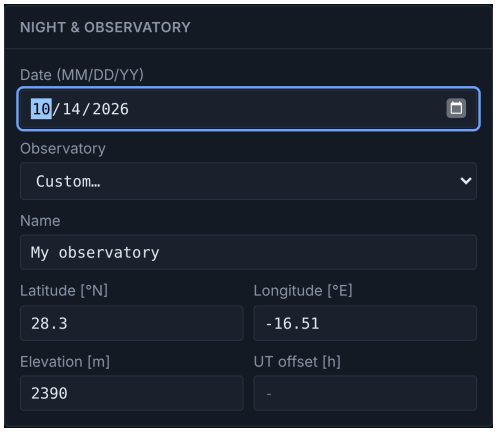
3. The BinarAlt Planner

BinarAlt is divided into three columns:

Column	Boxes	Purpose
Left	*Night & Observatory*, *Scheduler*, *Targets*, action buttons	Everything you enter: the night, the site, the scheduling rules and the targets.
Center	Legend, visibility plot, *Exposure Timeline*/*Observing Timeline*, *Observation Plan*/*Logbook*	Everything BinarAlt computes: altitude curves, the plan and the record of the night.
Right	*Weather*, *Time*, *Ephemeris*, *Countdown*, *Log*	Live information, updated every second (weather: see Sect. 6.1).

The **?** button in the top-right corner opens this guide (`BinarAlt_UserGuide.pdf`, next to `binaralt.html`) and the page to report an issue. While the weather alarm is ringing, a blinking bell button appears to its left (Sect. 6.1).

3.1. Night & Observatory



- **Date (night starting).** The date on which the night *starts* (its evening), shown in the date format of your browser. The night runs from the sunset of that date to the sunrise of the next day, at any longitude (Sect. 4.2). It defaults to the night in progress, in the local time of your computer: from 09:00 to midnight, today; from midnight to 09:00 (e.g. at 02:00, still observing), the previous day.

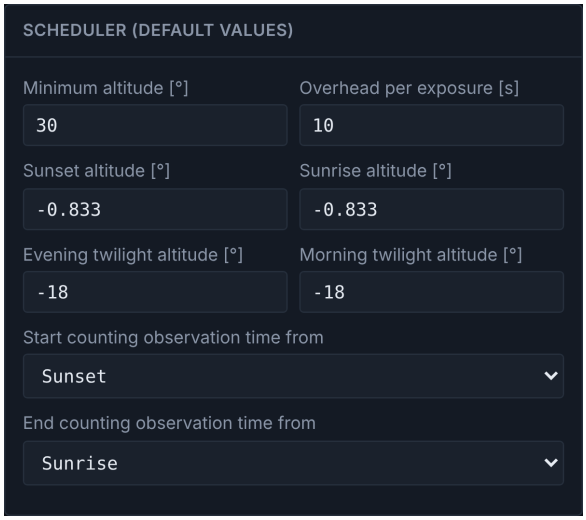
- **Observatory.** One of the eight pre-defined observatories of PANORAMA (table below), or *Custom…* to enter your own site: *Name*, *Latitude* [°N], *Longitude* [°E, negative to the West], *Elevation* [m] and *UT offset* [h]. The UT offset is only used for the observatory clock of a custom site (Sect. 6.2).

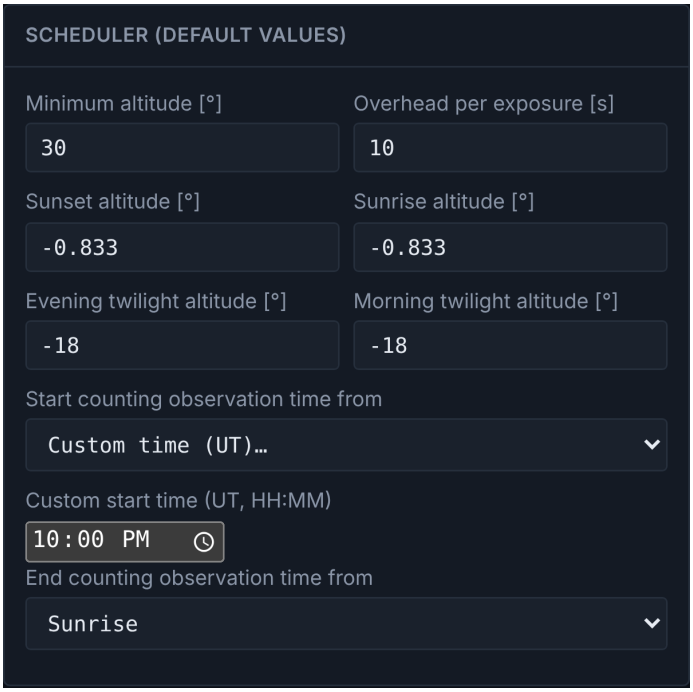
The pre-defined observatories are those of `panorama.obs`, with the same codes (e.g. `"ORM"` as the `observatory` argument of its functions) and coordinates, so both tools give the same ephemerides for them:

Code	Observatory	Lat. [°]	Lon. [°]	Elev. [m]	Time zone	Weather
OT	Observatorio del Teide (Tenerife, Spain)	+28.3000	−16.5097	2390	Atlantic/Canary	yes
ORM	Roque de los Muchachos (La Palma, Spain)	+28.7561	−17.8917	2396	Atlantic/Canary	yes
CAHA	Calar Alto Observatory (Almería, Spain)	+37.2236	−2.5461	2168	Europe/Madrid	no
OHP	Observatoire de Haute-Provence (France)	+43.9308	+5.7133	650	Europe/Paris	no
LASILLA	La Silla Observatory (ESO, Chile)	−29.2567	−70.7300	2400	America/Santiago	no
PARANAL	Paranal Observatory (ESO, Chile)	−24.6272	−70.4042	2635	America/Santiago	no
SAAO	SAAO (Sutherland, South Africa)	−32.3794	+20.8106	1798	Africa/Johannesburg	no
MAUNAKEA	Maunakea Observatories (Hawai'i, USA)	+19.8267	−155.4717	4205	Pacific/Honolulu	no

Latitudes are North positive and longitudes East positive. Live weather is only available for OT and ORM (Sect. 6.1); for the other sites, and for custom ones, the *Weather* box shows that there is no weather data access.

3.2. Scheduler (Observation Values)

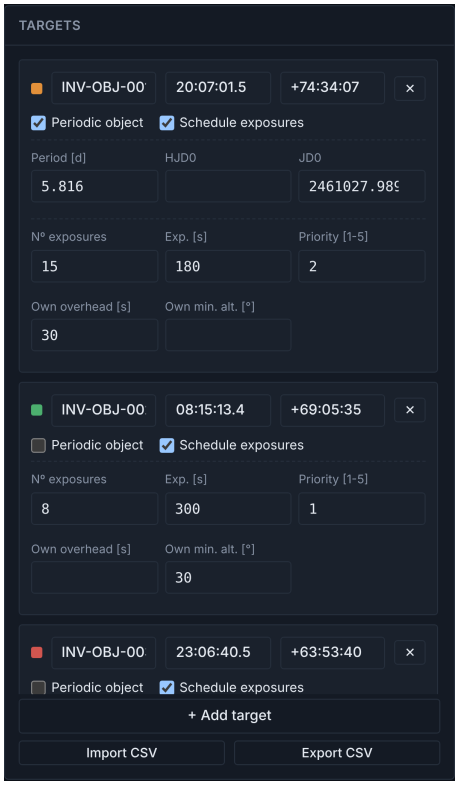




Field	Default	Description
Minimum altitude [°]	30°	Altitude below which a target is not observed (30° ≈ airmass 2). Each target can override it.
Overhead per exposure [s]	10 s	Time added to every exposure (read-out, offsets…). Each target can override it.
Sunset / Sunrise altitude [°]	$-0.833°$	Altitude of the center of the Sun that defines sunset and sunrise (solar radius plus standard refraction).
Evening / Morning twilight altitude [°]	$-18°$	Altitude of the center of the Sun that defines the end and start of the twilight ($-18°$: astronomical; $-12°$: nautical; $-6°$: civil).
Start / End counting observation time from	*Sunset* / *Sunrise*	Time interval the scheduler may use: sunset/sunrise, the twilights above, or a custom UT time (a time earlier than sunset, e.g. 02:00, belongs to the next calendar day).

Note. With the defaults, the scheduler uses the whole time between sunset and sunrise, including the twilights. In `panorama.obs` (`visibility`, `annual_visibility`, `obs_phase_night`, `periodic_event`) a target is only *observable* during the dark time, with the Sun below $-18°$. To plan with the same criterion, set *Start* and *End* to *Evening twilight* and *Morning twilight*.

3.3. Targets



Each target is a card. *+ Add target* adds an empty card, and the × of a card deletes it. A card is used only when its *Name*, *RA* and *Dec* are filled in; incomplete cards are ignored.

Required fields

Field	Accepted formats
Name	Any text.
RA	`18:36:56.3`, `18h36m56.3s`, `18 36 56.3` (hours), or `279d14m04.5s` and decimal **degrees** (`279.2346`). From 0 to 24 h (0 to 360°).
Dec	`+38:47:01`, `+38d47m01s`, `+38 47 01`, or decimal degrees (`38.7836`). From $-90°$ to $+90°$.

Coordinates are ICRS (J2000). Each card keeps its own color (and dash pattern, when colors repeat) in every plot and table.

> **Note.** As in `panorama.obs`, an RA written with `:`, `h` or spaces is read in *hours*, while a plain decimal number or a `d`-style value is read in *degrees* (`279.2346` = `18:36:56.3`). The declination is always read in degrees.

Periodic object

Tick *Periodic object* to show the orbital phases along the altitude curve and in the *Logbook*. It requires a period and one epoch:

Field	Description
Period [d]	Period in days (positive).
HJD0	Epoch of phase 0 (e.g. primary minimum) as a Heliocentric Julian Date (UTC).
JD0	Epoch of phase 0 as a (geocentric) Julian Date (UTC). *HJD0* takes precedence over *JD0*.

The ephemeris is applied in the time scale of the epoch that is given (Sect. 4.5): give the epoch as HJD0 whenever possible.

Schedule exposures

Tick *Schedule exposures* to include the target in the scheduler:

Field	Description
Nº exposures	Number of individual exposures (required, positive whole number).
Exp. (s)	Time of each exposure in seconds (required, positive).
Own overhead (s)	Overhead per exposure for this target; empty = global value of *Scheduler*.
Own min. alt. (°)	Minimum altitude for this target; empty = global value of *Scheduler*.
Priority (1–5)	1 = highest, 5 = lowest; empty or invalid = 3.

The block of a target lasts $N_{\mathrm{exp}} \times (t_{\mathrm{exp}} + \mathrm{overhead})$. Once a target enters the plan, its card is hidden from *Targets* (it is still used in every recomputation), and it reappears if the target falls out of the plan after a new *Plan Observation*.

> **Tip.** Import a whole target list with *Import CSV*, and save the current one with *Export CSV* (Sect. 9).

3.4. Action Buttons

Button	What it does
Plot Targets	Computes the night and draws the altitude curves of the current targets. An existing plan is kept, not recomputed.
Plan Observation	Computes the night, runs the scheduler and draws the curves together with the plan.
Save session / *Load session*	Saves or restores the complete page state to/from a JSON file (Sect. 9).
Clear All	Resets the page to its initial state (the current night, one demo target, Vega) and deletes the copy saved in the browser. It cannot be undone.

Nothing is recomputed automatically: after editing a target or a setting, click *Plot Targets* or *Plan Observation* again. Both buttons clear the *Log* before writing their own messages.

4. Astronomical Definitions

This section describes how BinarAlt computes every quantity, and how it compares with `panorama.obs`. All the calculations use the Astronomy Engine library (bundled in the page) and the observatory latitude, longitude and elevation.

4.1. Times and time scales

- All times in plots, tables and boxes are **UT** (UTC), in 24-hour format. The only exceptions are the *Your local time* and *Observatory time* clocks, and the timestamps of the *Log* (local time of your computer).
- JD is the Julian Date in UTC. HJD is the Heliocentric Julian Date (UTC), HJD $=$ JD $+\,\Delta t$, where Δt is the light-travel time between the Earth and the Sun projected onto the direction of the target (up to ± 8.3 min, changing through the year). It depends on the target, so BinarAlt only uses it for periodic objects, and the *Time* box shows the JD, not an HJD.

4.2. The night

- **Which night.** The night of a given *Date* is the one that starts in the evening of that local date. The search for its events starts at the mean local noon (12:00 UT minus longitude$/15$ h), so the right night is found at every longitude, as in `panorama.obs`.
- **Sunset and sunrise**: the center of the Sun at -0.833° (geometric altitude). The visibility plot spans from 30 min before sunset to 30 min after sunrise.
- **Twilights**: the center of the Sun at the twilight altitude of *Scheduler* (default -18°, astronomical twilight). The **dark time** lies between the evening and morning twilights. Where the Sun never reaches that altitude (e.g. no astronomical night in summer at high latitudes), the twilights are shown as – and are not used.
- **Local midnight**: the true solar midnight, when the Sun crosses the meridian below the horizon (hour angle of 12 h). It differs from the mean local midnight (00:00 UT minus longitude$/15$ h) by the equation of time (up to $\sim$16 min).

With the default thresholds, these times agree with `night_info` and `visibility` to a few seconds.

4.3. Positions, altitude and airmass

- Target coordinates are ICRS (J2000), converted to the apparent position of date (precession, nutation and aberration) as seen from the observatory.
- **Altitude**: geometric altitude, without atmospheric refraction (as in `panorama.obs`, where the pressure is set to 0). Refraction would raise objects by $\sim$1.7 arcmin at 30° and $\sim$35 arcmin at the horizon.
- **Airmass**: $X = \sec z = 1/\sin(\mathrm{alt})$, accurate to $\sim$1 % for $z < 70^\circ$ ($X < 3$); undefined below the horizon.
- **LST**: local apparent sidereal time. A target transits (reaches its maximum altitude) when LST $\approx$ RA.
- **Time grid**: each altitude curve is sampled at 200 points across the plotted night ($\sim$4 min apart), and intermediate values are interpolated linearly. The visibility windows of the scheduler are read from these samples, so their limits are accurate to a few minutes (`panorama.obs` interpolates the crossings and reaches a few seconds).

4.4. The Moon

- **Moonrise and moonset**: the geometric center of the Moon crossing 0° (no refraction, no limb correction), as in `panorama.obs`. For the planning night, only the events that happen between sunset and sunrise are shown; otherwise they appear as –.
- **Illumination**: illuminated fraction of the lunar disk at the local midnight, in percent. As a rough guide, $\lesssim 25$ % is dark time and $\gtrsim 50$–70 % with the Moon above the horizon is bright time.
- **Moon distance**: angular separation between the target and the Moon (apparent positions of date).

4.5. Phases of periodic objects

The phase of a periodic object at a time t is

$$\phi = \frac{(t - T_0) \bmod P}{P}, \qquad 0 \le \phi < 1,$$

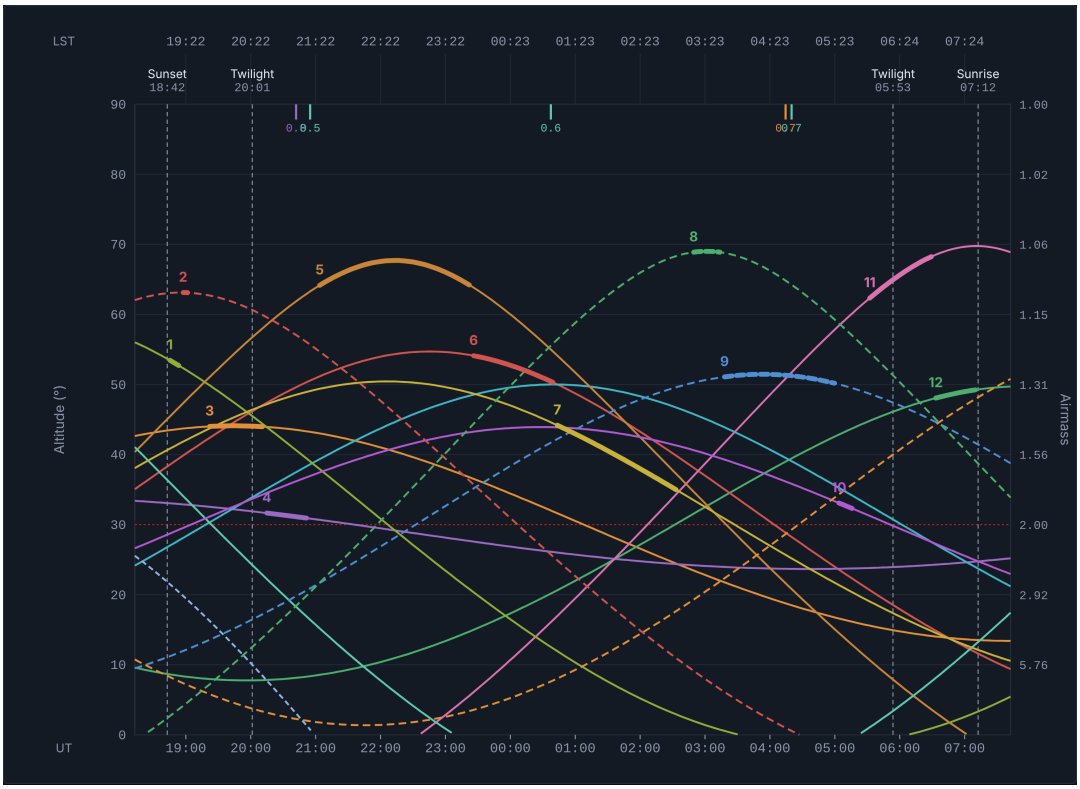
with the linear ephemeris $T(E) = T_0 + E\,P$ applied in the time scale of the epoch, exactly as `obs_phase`, `periodic_event` and `obs_phase_night` do:

- **With HJD0**: t and T_0 are both HJD. Each time is converted to HJD with the light-travel time toward the target at that date, and each phase mark on the plot is computed in HJD and converted back to UT.
- **With JD0 only**: t and T_0 are both JD.

> **Note.** A binary is periodic as seen from the Sun, not from the Earth: as the Earth moves along its orbit, the eclipses arrive up to ∼8.3 min earlier or later. An ephemeris given in JD ignores this, so its predictions drift by the change of the light-travel time between the epoch and the event (up to ∼16 min). Give the epoch as HJD0 whenever possible.

5. Plots and Tables

5.1. Visibility Plot



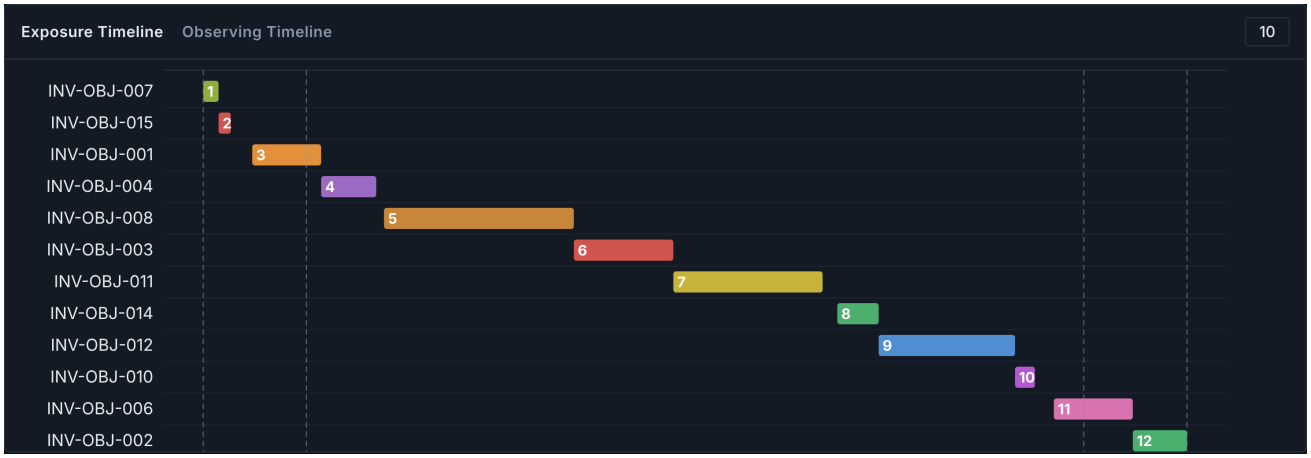
- **Altitude axis (left)**, from 0° to 90°. The red dotted line marks the *Minimum altitude* of *Scheduler* (30° by default, airmass 2) and follows it when it is changed. The own minimum altitude of a target, if any, is not drawn.
- **Airmass axis (right)**: $\sec z$ at each altitude grid line.
- **Time axes**: UT at the bottom, and LST at the top (on each UT hour).
- **Sunset** / **twilight** / **sunrise**: dashed vertical lines, labeled with their UT times.
- **Moon**: dashed blue curve, drawn while the Moon is above the horizon.
- **Target curves**: drawn only above the horizon.
- **Phase marks** (periodic objects): ticks along the top edge every 0.1 in phase, labeled with the phase.
- **Planned blocks** (after *Plan Observation*): thick segments on the curves, labeled with their order in the plan (also very short blocks, of less than a few minutes). A dotted segment marks a *compromised* block, placed away from the best time of the target (Sect. 7.2).
- **Now**: a red dashed vertical line at the current UT time, when it falls within the plotted night.
- **Time tooltip**: hovering over the plot shows a crosshair and the UT time at that position.

> **Tip.** Clicking a target (its curve, its legend entry, its row in any table or its bar in any timeline) highlights it everywhere, dims all the others, and scrolls every table and timeline to its row. Clicking it again clears the highlight. Clicking the Moon in the legend only highlights its curve.

5.2. Timelines

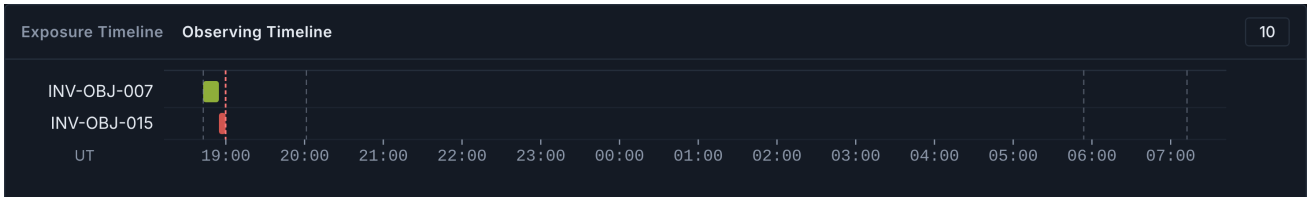
Both tabs share the time axis of the visibility plot, so the three panels can be read together. *Max rows* sets how many rows are shown before the box scrolls.

5.2.1. Exposure Timeline



A Gantt view of the plan: one row per scheduled target, with a bar from its planned start to its planned end, in the color of its curve. Targets that could not be scheduled do not appear: if a target is missing, read *Log* for the reason (Sect. 10). Gaps between bars are times with no target scheduled, where another block could fit.

5.2.2. Observing Timeline



The real-time counterpart of the *Exposure Timeline*: what has actually been observed. A row appears when a target is started (*Observing*), in the order in which targets were started. Its bar begins at the real start time, grows with the clock while the target is *Observing*, and stops at the real end time once it is *Observed*. Resetting a target to *Not observed* clears its times and removes its row.

Comparing both tabs shows how the night is going: bars that start later than planned signal a delay, and shorter bars an integration shorter than planned. If the delay accumulates, click *Plan Observation* again (Sect. 7.4).

5.3. Observation Plan and Logbook

Both tabs share *Max rows*, *Undo* and *Delete all*.

5.3.1. Observation Plan

Observation Plan Logbook 10 Undo Delete all

	#	Target	Coordinates	Priority	Start	End	N° exp.	Exp. [s]	Overhead [s]	Min Alt [°]	Init Alt [°]	Mean Alt [°]	Max Alt [°]	Moon Dist [°]
×	1	INV-OBJ-007	17:12:43 +59:49:18	1	18:42	18:54	5	120	20	40.0	53.7	53.1	53.7	87.8
×	2	INV-OBJ-015	19:16:48 +55:34:46	3	18:54	19:03	8	60	10	30.0	63.1	63.1	63.1	90.9
×	3	INV-OBJ-001	20:07:02 +74:34:07	2	19:20	20:12	15	180	30	30.0	44.0	44.0	44.1	108.1
×	4	INV-OBJ-004	17:05:35 +84:56:55	3	20:12	20:54	18	120	20	30.0	31.7	31.3	31.7	112.4
×	5	INV-OBJ-008	22:34:25 +50:54:14	2	21:00	23:25	28	300	10	25.0	63.8	65.8	67.7	111.8
×	6	INV-OBJ-003	23:06:40 +63:53:40	3	23:25	00:41	14	300	25	35.0	54.1	52.4	54.1	118.0
×	7	INV-OBJ-011	22:27:20 +68:10:23	3	00:41	02:34	21	300	25	25.0	44.4	39.7	44.4	114.3
×	8	INV-OBJ-014	03:22:51 +49:38:40	1	02:45	03:17	21	60	30	30.0	68.8	68.9	69.0	153.0
×	9	INV-OBJ-012	04:13:57 +67:13:42	3	03:17	05:01	29	180	35	30.0	51.1	51.0	51.4	139.8
×	10	INV-OBJ-010	00:48:48 +74:40:53	5	05:01	05:16	13	60	10	30.0	33.2	32.8	33.2	124.1

The plan computed by the scheduler, in chronological order:

Column	Description
×	Removes the target from the plan and re-runs the scheduler.
#	Order in the plan (same number as on the plot).
Target, *Coordinates*, *Priority*	As entered; coordinates in sexagesimal notation.
Start, *End*	Planned UT start and end of the block.
N° exp., *Exp. [s]*, *Overhead [s]*	Exposure setup used to compute the block length.
Min Alt [°]	Minimum altitude applied to this target.
Init / Mean / Max Alt [°]	Altitude at the start of the block, and its mean and maximum over the block (5 samples).
Moon Dist [°]	Mean distance to the Moon over the block (5 samples); orange $< 30°$, red $< 10°$.

Targets that could not be scheduled are listed at the end, in red, continuing the numbering. Their *Start* and *End* show their visibility window, not a real slot, and hovering over the row shows the reason, which is also written in *Log*:

- the night is full while the target is visible (*could not fit . . . without overlapping*);
- every possible placement dips below its minimum altitude (*every fit still dips below its altitude limit*);
- the target is only visible outside the scheduling start/end times (*only visible outside the chosen scheduling start/end window*).

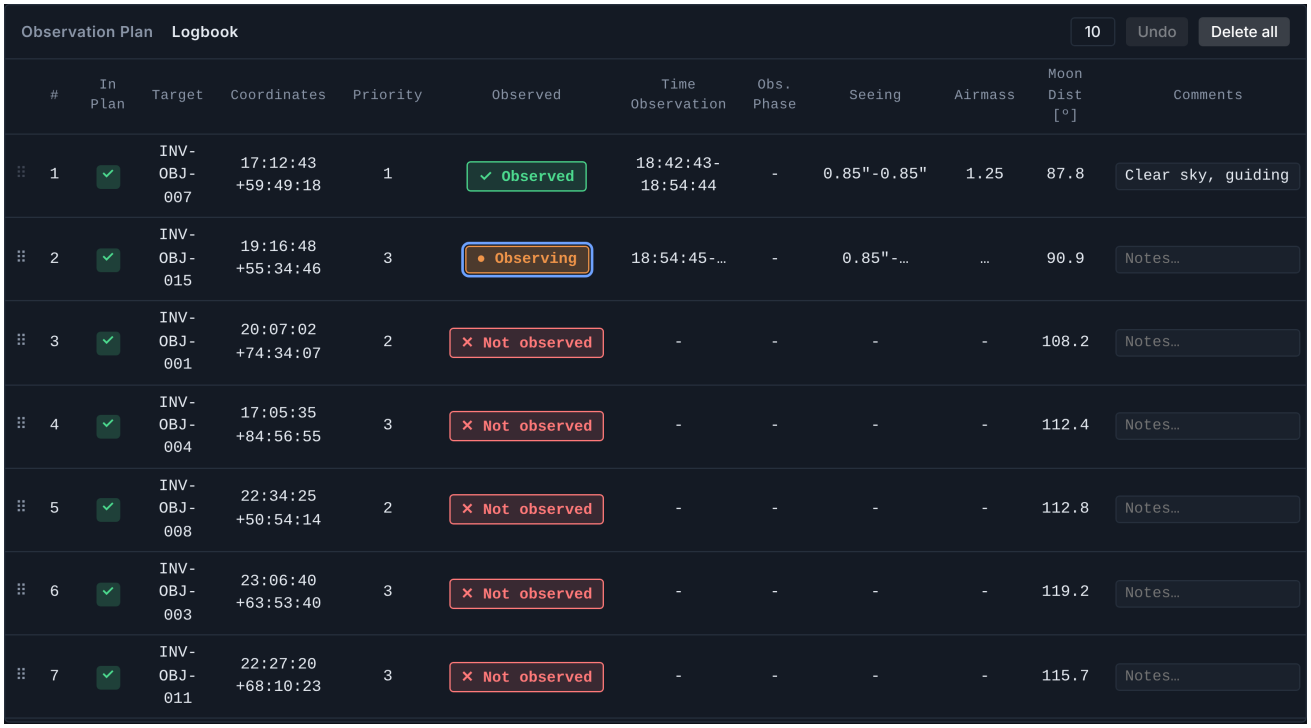
Targets that never reach their minimum altitude are not candidates at all: they are only reported in *Log* and listed in the *Logbook* as not in the plan.

×	13	INV-OBJ-009	14:37:17 +51:24:17	1	18:54	21:23	28	300	20	30.0	34.5	23.3	34.5 *	82.2
×	14	INV-OBJ-013	10:06:06 +62:44:59	4	04:27	07:12	10	240	10	30.0	30.1	39.4	48.2	119.1
×	15	INV-OBJ-005	01:01:06 +68:36:12	4	05:01	05:23	10	120	10	35.0	35.5	34.5	35.5 *	127.3

Editing the plan:

- × (per row) removes the target from the plan (its card is deleted from *Targets*) and re-optimizes the rest. The target stays in the *Logbook* as *not in plan*. Observed targets cannot be removed.
- *Delete all* removes every target from the plan *and* from *Targets*, together with the *Logbook*, after confirmation.
- *Undo* reverts the last removal, *Delete all* or *Logbook* reordering (up to 20 steps; dropping a row back in its own place is not a change). The *Observing*/*Observed* clicks are not undone.

5.3.2. Logbook

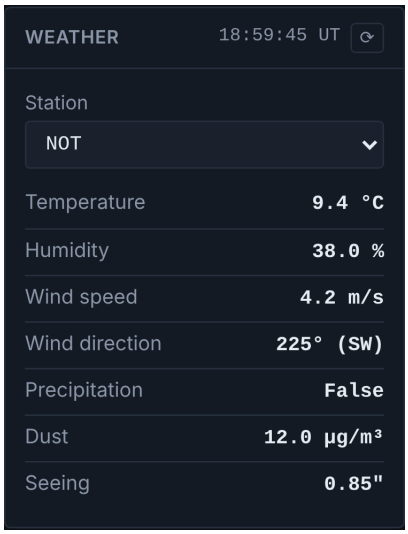


The record of the night, one row per target of the plan (and per target removed from it or never reaching its minimum altitude):

Column	Description
Drag handle (*#*)	Reorders the rows (display only; the plan is not changed). Observed rows are locked.
In Plan	✓ in the plan; × removed from it or not scheduled. A target removed from the plan cannot be started.
Observed	Status button: *Not observed* → *Observing* → *Observed* → back to *Not observed* (Sect. 8).
Time Observation	Real UT start and end times.
Obs. Phase	Phase range covered between the real start and end (periodic objects only; Sect. 4.5).
Seeing	Median of the seeing readings sampled every 30 s while *Observing* (plus the reading at the end click), in the units of the station; n/a if no reading was available.
Airmass	Mean airmass between the real start and end (5 samples).
Moon Dist [°]	Current distance to the Moon, updated every second: orange $< 30°$, red $< 10°$.
Comments	Free-text notes, saved with the session. For a target that could not be scheduled, the reason is written automatically; it is updated with each new plan (and cleared once the target is scheduled), but a comment written by you is never replaced.

6. Live Information

6.1. Weather



Live readings from the selected weather station: temperature, humidity, wind speed and direction, precipitation, dust and seeing, as reported by the station (parameters it does not provide are shown as −). The header shows the UT time of the last successful reading, and the ↻ button forces an immediate refresh.

Readings refresh automatically every **5 min**, or every **30 s** while any target is *Observing* or any parameter exceeds its limit. Every *Observed* click also forces a fresh reading, so the seeing recorded in the *Logbook* reflects the conditions of each observation.

If a station does not answer, the header shows `n/a`, the values are shown as − and an error is logged: choose another station until it recovers. A failed reading does not clear an ongoing alert: the alert and the alarm of the last good reading are kept. Only OT and ORM have weather stations; for any other observatory (pre-defined or custom) the box shows that there is no weather data access, and any previous alert is cleared.

Available weather stations

Observatory	Stations
OT	SONG, STELLA, SPECULOOS
ORM	NOT (default), TNG, GTC, INT, MAGIC, Liverpool Telescope

Weather limits

Values above these limits are highlighted in the color of their level, and a message is logged once when a limit is crossed and once when the value is back within it:

Parameter	Yellow	Orange	Red
Humidity	$> 60\,\%$	$> 70\,\%$	$> 80\,\%$
Wind speed	$> 10\,\mathrm{m\,s^{-1}}$	$> 12\,\mathrm{m\,s^{-1}}$	$> 14\,\mathrm{m\,s^{-1}}$
Dust	$> 50\,\mu\mathrm{g\,m^{-3}}$	$> 100\,\mu\mathrm{g\,m^{-3}}$	$> 150\,\mu\mathrm{g\,m^{-3}}$
Precipitation	—	—	any reading other than dry or zero

Yes/no precipitation sensors are shown as `False` (dry) or `True`; numeric readings are shown as reported.

Box alerts and alarm

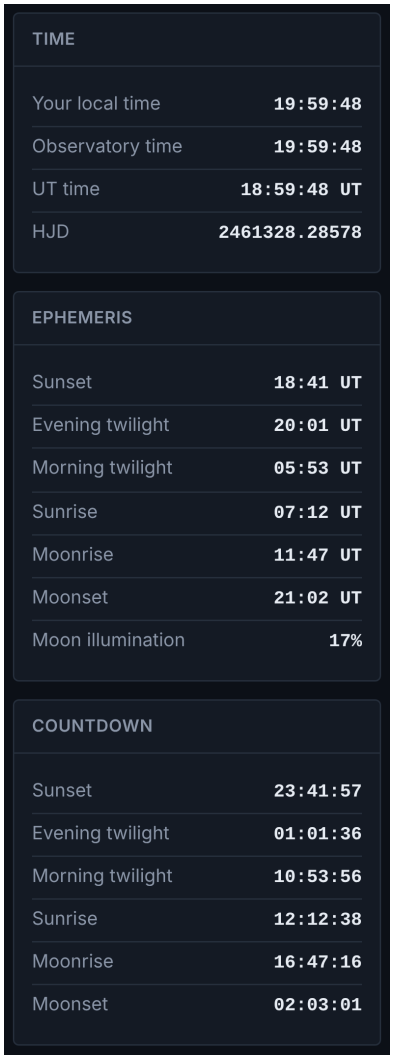
While any reading is above its limit, the overall (worst) level of all readings is also shown on the boxes that matter during the night:

- **Box alerts.** The *Weather*, *Observation Plan*/*Logbook* and *Exposure Timeline*/*Observing Timeline* boxes take a border in the color of the level (yellow, orange or red) and a light tint of the same color. At the red level, their borders blink. The boxes return to normal as soon as every reading is back within its limits.
- **Alarm.** When a reading reaches the **red** level, an alarm sounds (a repeated beep) and a blinking bell button appears next to the **?** button (top-right corner). Clicking the bell silences the alarm and hides the button; the box alerts stay on. Yellow and orange levels never sound.
- **Re-arming.** Once the level drops below red, the alarm is armed again: the next time a reading reaches the red level it sounds again, even if it had been silenced before. It also sounds if a red limit is already exceeded when BinarAlt is opened.

Note. Browsers do not play sound on a page until the user has interacted with it. If the alarm is triggered before any click or key press (e.g. right after opening BinarAlt), the box alerts and the bell are shown at once, but the sound only starts after the first click or key press anywhere on the page. Keep the volume of the computer on during the night.

Tip. These limits are only reminders. The decision to close the dome follows the rules of each telescope and the instructions of its operators.

6.2. Time, Ephemeris and Countdown



Time. Four clocks, updated every second:

- *Your local time*: the time of the computer running the browser.
- *Observatory time*: civil time at the site, from the time zone of the predefined observatory (including daylight saving time; Sect. 3.1). For a custom site, UT plus its *UT offset* (no daylight saving); – if no offset is given.
- *UT time*: Universal Time, the reference of all plots and tables.
- *JD*: Julian Date (UTC) of the current moment.

Ephemeris. The events of the night being planned (the date in the box header), with the definitions of Sect. 4:

- *Sunset* / *Sunrise* and *Evening* / *Morning twilight*, with the Sun altitudes of *Scheduler*;
- *Moonrise* / *Moonset* during that night (– if they do not happen between sunset and sunrise);
- *Moon illumination* at the local midnight.

Without a date, the next occurrence of each event from now is shown instead.

Countdown. Time left from *now* until each event of the *Ephemeris* box, recomputed every second. Since the events belong to the planning night, the countdown is meaningful also when preparing a future night (e.g. how long until the sunset of that night). Events already passed show `00:00:00`.

6.3. Log

Log reports input problems, scheduler results, targets left out and why, observation times, weather updates, limit crossings and Moon-distance warnings. Messages are shown newest first, with the local time of your computer, and colored by level: information (blue), success (green), warning (orange) and error (red). *Plot Targets* and *Plan Observation* clear it before writing their own messages. Section 10 lists the messages and what to do.

7. The Scheduler

Plan Observation places one contiguous block per target, of length $N_{\mathrm{exp}} \times (t_{\mathrm{exp}} + \mathrm{overhead})$, between the scheduling start and end times of *Scheduler*. Its goals, in strict order of importance:

1. Observe as many **high-priority** targets as possible.
2. Then, observe as many targets as possible in total.
3. Then, observe each target as **high in the sky** as possible.

7.1. Step 1: Candidates and Visibility Windows

Every target with *Schedule exposures* ticked is checked. Its visibility window is the continuous interval around its maximum altitude in which it stays at or above its minimum altitude, limited to the scheduling start/end times.

- A target that never reaches its minimum altitude is left out (warning in *Log*).
- A target whose window lies entirely outside the scheduling start/end times is listed as not scheduled.
- Every other target becomes a candidate.

7.2. Step 2: Placing the Blocks

Candidates are placed one after another, in a given order (Step 3):

- Each block is placed in the free time of its window, with its center as close as possible to the maximum altitude of the target, without overlapping the blocks already placed.
- If it does not fit in its window, it is placed in the free time closest to that maximum anywhere between the scheduling start and end, and flagged **compromised** — but only if it stays above the minimum altitude during the whole block (checked at 5 points). Otherwise it is listed as not scheduled.
- If it fits nowhere, it is listed as not scheduled.

7.3. Step 3: Choosing the Best Order

The result of Step 2 depends on the order in which the candidates are placed. The scheduler therefore builds seven candidate plans, one per ordering strategy, and keeps the best one. Every strategy sorts the targets by **priority first**, and uses its own criterion only within each priority level, so priority-1 targets always get the first choice of time.

7.3.1. Ordering Strategies

1. **Earliest window end.** Targets whose windows close first go first, so that targets about to set are not missed.
2. **Earliest window start.** Follows the progression of visibility through the night.
3. **Shortest block.** Short blocks fit into small gaps and may increase the number of scheduled targets, but long blocks may then be hard to place.
4. **Longest block.** Long blocks go first, before shorter ones take the time they need.
5. **Least slack.** Targets with the least margin go first, with the slack of target i defined as

$$\mathrm{slack}_i = (t_{i,\mathrm{end}} - t_{i,\mathrm{start}}) - d_i,$$

   where $t_{i,\mathrm{start}}$ and $t_{i,\mathrm{end}}$ are the limits of its window and d_i its block duration. It measures the flexibility within the window, not the conflicts with other blocks.
6. **Highest maximum altitude.** Favors targets that culminate high.
7. **Lowest maximum altitude.** Places the less favorable targets first and leaves the more flexible ones to fill the remaining gaps.

7.3.2. How Candidate Plans Are Compared

The seven plans are compared with these criteria, in strict order of precedence:

1. **Number of scheduled targets at each priority**, from priority 1 to 5: more priority-1 targets always wins, then priority 2 breaks ties, and so on. Extra low-priority targets never compensate for a missing higher-priority one.
2. **Total number of scheduled targets.**
3. **Sum of the mean altitudes of the blocks**,

$$A_{\text{sum}} = \sum_{i=1}^{N} \overline{h}_i,$$

where $\overline{h}_i$ is the mean altitude of block i (5 samples across the block).

7.3.3. Final Output

The blocks of the best plan are sorted by start time and numbered. Targets that could not be scheduled are appended at the end, continuing the numbering; their position is only a reporting convention, not a slot at the end of the night.

> **Note.** The selected plan is the best of the seven candidate plans, not necessarily the best of all possible plans. Testing several orderings explores different possibilities, but it does not guarantee a global optimum.

7.4. Re-planning During the Night

Plan Observation can be clicked again at any time:

- Targets already *Observed* keep their real place and are never moved.
- Targets added since the last plan are only placed after the current time and after the planned end of the target being observed. This only applies while the night is in progress: for a future night *now* is before every window, and a night already over is planned as a whole.
- The rest of the plan is optimized again.

Planning another night. When the *Date* or the observatory is changed and the night is computed again (*Plot Targets* or *Plan Observation*), the previous plan belongs to another night: it is not carried over, and no target keeps its old place. The *Logbook* starts again: every target goes back to *Not observed* (times, seeing and comments cleared), and the row order and the targets removed from the plan are dropped. If something you recorded is cleared, a message is logged and *Undo* brings the previous night back. Save the session before changing the night to keep its *Logbook*.

To fit more targets into the night:

- Look for gaps in the *Exposure Timeline*: a short target visible in a gap will fit.
- Shorten long blocks (fewer or shorter exposures), or reduce overheads if overestimated.
- Lower the minimum altitude of targets bright enough for it.
- Widen the usable time (start at sunset rather than twilight) if the targets allow it.
- Use priorities: 1 for what must be observed tonight, 4–5 for fillers.

8. Recording the Observing Night

A typical sequence for each target, in the *Logbook*:

1. **Start.** Click *Not observed* when the first exposure starts. The button turns into *Observing*: BinarAlt forces a fresh weather reading, records the UT time and starts sampling the seeing every 30 s. Its bar starts growing in the *Observing Timeline*.
2. **End.** Click *Observing* when the last exposure ends. The button turns into *Observed*: BinarAlt forces a fresh weather reading and records the end time, the median seeing of all samples, the mean airmass and, for periodic objects, the phase range covered. The row locks in place.
3. **Notes.** Write anything worth remembering in *Comments*.

> **Tip.** A third click on *Observed* resets the target to *Not observed* and clears its times and seeing, in case of a mistaken click.

> **Tip.** When the night does not go as planned:
>
> - **Running late or early.** Click *Plan Observation* again; observed targets stay fixed.
> - **Dropping a target.** Remove it with its × button in the *Observation Plan*; it stays in the *Logbook* as *not in plan*.
> - **Adding a target.** Add a card, fill it in and click *Plan Observation*.
> - **Moon too close.** If *Moon Dist* turns orange or red, consider postponing the target.

After the night, save the session. The JSON file contains the real start and end times (UT), the seeing readings and the comments of every target, ready for the observing report or for the `obs` module of PANORAMA (e.g. `bary_corr` for barycentric corrections and $\mathrm{BJD_{TDB}}$, or `obs_phase` for the phases of each spectrum).

9. Files: Targets CSV and Sessions

9.1. Targets CSV

Import CSV reads a comma-separated file with a header row. The column names must be written exactly as below (the same as *Export CSV* writes); their order is free, and only `Name`, `RA` and `Dec` are required:

```
Name,RA,Dec,Period (d),HJD0,JD0,N° exposures,Exp. (s),Own overhead (s),Own min. alt. (
    °),Priority (1-5)
INV-OBJ-001,20:07:01.5,+74:34:07,5.816,,2461027.98952,15,180,30,,2
INV-OBJ-002,08:15:13.4,+69:05:35,,,,8,300,,30,1
```

Column	Required	Content
`Name`	yes	Target name. Rows with an empty name are skipped.
`RA`	yes	Right ascension (sexagesimal hours, or decimal degrees; Sect. 3.3).
`Dec`	yes	Declination (sexagesimal or decimal degrees).
`Period (d)`	no	Period in days; ticks *Periodic object*.
`HJD0`, `JD0`	no	Epoch of phase 0 (one of them, with a period; HJD0 preferred).
`N° exposures`	no	Number of exposures; ticks *Schedule exposures*.
`Exp. (s)`	no	Exposure time in seconds.
`Own overhead (s)`	no	Overhead per exposure; empty = global value.
`Own min. alt. (°)`	no	Minimum altitude; empty = global value.
`Priority (1-5)`	no	1 = highest, 5 = lowest; empty = 3.

- Importing **replaces** the current target list.
- Columns with any other name are ignored, so check the spelling of `N° exposures` and `Own min. alt. (°)` (a column named differently is read as empty).
- Fields containing commas must be quoted.
- *Export CSV* saves the complete targets to `binaralt-targets.csv`, which can be re-imported on another computer or night.

9.2. Session file

Save session writes `binaralt-session.json`, a JSON file with:

Content	Details
Night and site	Date, observatory and custom observatory fields.
Scheduler	All values of the *Scheduler* box.
Display	Weather station and *Max rows* of both tabbed boxes.
Targets	Every card, with all its fields, color and dash pattern.
Logbook	Status, real start and end times (UT, ISO 8601), seeing readings, comments, row order and targets removed from the plan.

Load session restores it in any browser and, if the session had a plan, computes it again; observed targets keep their recorded place. The same state is also saved automatically in the browser (local storage, key `binaralt-state`) after every action and restored when the page is reopened. A state saved by earlier versions under the key `staralt-state` is read once and moved to the new key.

10. Log Messages and Troubleshooting

In the messages below, *X* is a target name, *N* a number and *S* a weather station.

Message	Meaning and action
Inputs	
Pick a date first.	The date field is empty.
Invalid observatory latitude, longitude, or elevation.	A custom observatory field is empty or not a number.
Invalid sunset/sunrise/twilight altitude threshold.	A Sun altitude in *Scheduler* is empty or not a number.
Error computing the night window: . . .	The Sun does not set or rise at this site and date (polar day or night).
No targets have a complete name, RA and Dec.	Every card is missing a required field.
'X': Unrecognized RA (Dec): . . . ; skipped.	Check the coordinate format of X (Sect. 3.3).
'X': RA out of range (0-24 h, or 0-360° in degrees): . . . ; skipped.	The RA is negative or not below 24 h (360°).
'X': Dec out of range (-90° to +90°): . . . ; skipped.	The declination is larger than 90° in absolute value.
None of the targets have valid coordinates.	No coordinate could be read.
'X': the period must be positive; ephemeris ignored.	Enter a period larger than zero.
'X': HJD0 or JD0 is missing for the given period; ephemeris ignored.	Add *HJD0* or *JD0*, or untick *Periodic object*.
'X': both HJD0 and JD0 were given; using HJD0.	Informational: HJD0 takes precedence.
'X': number of exposures and exposure time must both be given (must be positive); not scheduled.	Fill in both with positive values, or untick *Schedule exposures*.
'X': the number of exposures must be a whole number; not scheduled.	Enter a whole number of exposures.
'X': priority must be a whole number from 1 (highest) to 5 (lowest); ignoring, using 3.	Enter a whole number between 1 and 5.
Scheduler	
'X' never reaches N° of altitude tonight; left out of the plan.	X is too low for its limit at this site and date.
'X' is only visible outside the chosen scheduling start/end window; left out of the plan.	Widen the start/end times in *Scheduler*.
Could not fit 'X' into the night without overlapping other targets; left out.	The night is full while X is visible.
'X': could not be scheduled — every fit still dips below its N° altitude limit at some point.	The block is longer than the free time X spends above its limit.
'X' is observed outside its N° window: the night was too full to place it near its peak.	Compromised placement: X is observed away from its best time.
Plan computed: N of M schedulable target(s) observed.	Summary of the plan.
During the night	
'X': too close to the Moon (N°) — cannot be observed.	The Moon is closer than 30° (warning) or 10° (error).
Cannot remove 'X': it has already been observed.	Reset its status first if the click was a mistake.
'X': removed from the observation plan.	X stays in the *Logbook* as not in plan and cannot be started.
Humidity (Wind speed, Dust, Precipitation) exceeded its limit of . . .	A weather limit was crossed (Sect. 6.1).
Weather alarm: a red weather limit is exceeded. Click the bell (top right) to silence it.	A reading reached the red level; the alarm is sounding (Sect. 6.1).
Weather alarm silenced (. . .).	The bell was clicked; the box alerts stay until the weather is back within limits.
New night: the logbook of the previous night was cleared and every target is "Not observed" (. . .).	The date or site was changed: the *Logbook* starts the new night (Sect. 7.4).

Message	Meaning and action
Weather data for S could not be retrieved.	Station S did not answer; choose another.
Running as a web page: live weather is disabled.	The page was not opened with `panorama.binaralt()`.
Files	
CSV header must include at least "Name", "RA" and "Dec".	Check the header row of the CSV file.
The file is not a BinarAlt session.	The JSON file chosen in *Load session* was not written by BinarAlt.
Nothing to save: add at least one target first.	A session needs at least one complete target.

Other questions.

- **The browser did not open.** Copy the address printed in the terminal into the browser (Sect. 2.1).
- **The plot did not change after editing a target.** Click *Plot Targets* or *Plan Observation*; nothing is recomputed automatically.
- **A target card disappeared.** Cards of targets in the plan are hidden from *Targets*; they come back if the target leaves the plan. Targets removed with × or *Delete all* are deleted.
- **Times differ slightly from `panorama.obs`.** Sun and Moon events agree to a few seconds; the visibility windows of the scheduler are read from a ∼4-min grid and the default scheduling interval includes the twilights (Sect. 4).
- **The alarm does not sound.** The browser plays no sound until the page has been clicked or a key pressed (Sect. 6.1); check also the volume of the computer.
- **I lost my targets after *Clear All*.** It also deletes the copy saved in the browser. Use *Load session* or import the CSV again.