Observing Proposal

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Prepared for: Observing Nights at AS Vidojevica (29–30 November 2024)
Telescope: 1.4m Milanković Telescope
Principal Investigators (PIs): Prof. Andjelić & Prof. Ilić

1. Galactic Supernova Remnant Pa30

This observing program focuses on the Galactic supernova remnant **Pa30** (also known as SN1181). The aim is to obtain high-quality, deep images using narrow-band Hα and [SII] filters, as well as a broad-band R filter. These observations will help analyze the remnant's ionized regions, structural features, and surrounding environment.

1.1 Observation Plan

Data Source:

The observation data will be collected from The Astronomical Station Vidojevica. It was established by the Astronomical Observatory of Belgrade and is located on Mt. Vidojevica near Prokuplje at an elevation of 1150 meters. Over the years, significant developments have taken place at the site. A living pavilion (serving as the main headquarters) and a dome for the 60cm telescope have been constructed. The summit of Mt. Vidojevica was designated for the installation of the new "Milanković" telescope. This advanced 1.4m AZ1400 "Milanković" telescope arrived on April 28, 2016, and was initially housed in a temporary roll-roof pavilion. It now resides in a state-of-the-art pavilion equipped with an automated dome, along with an auxiliary building that houses technical equipment, service facilities, and computer systems.

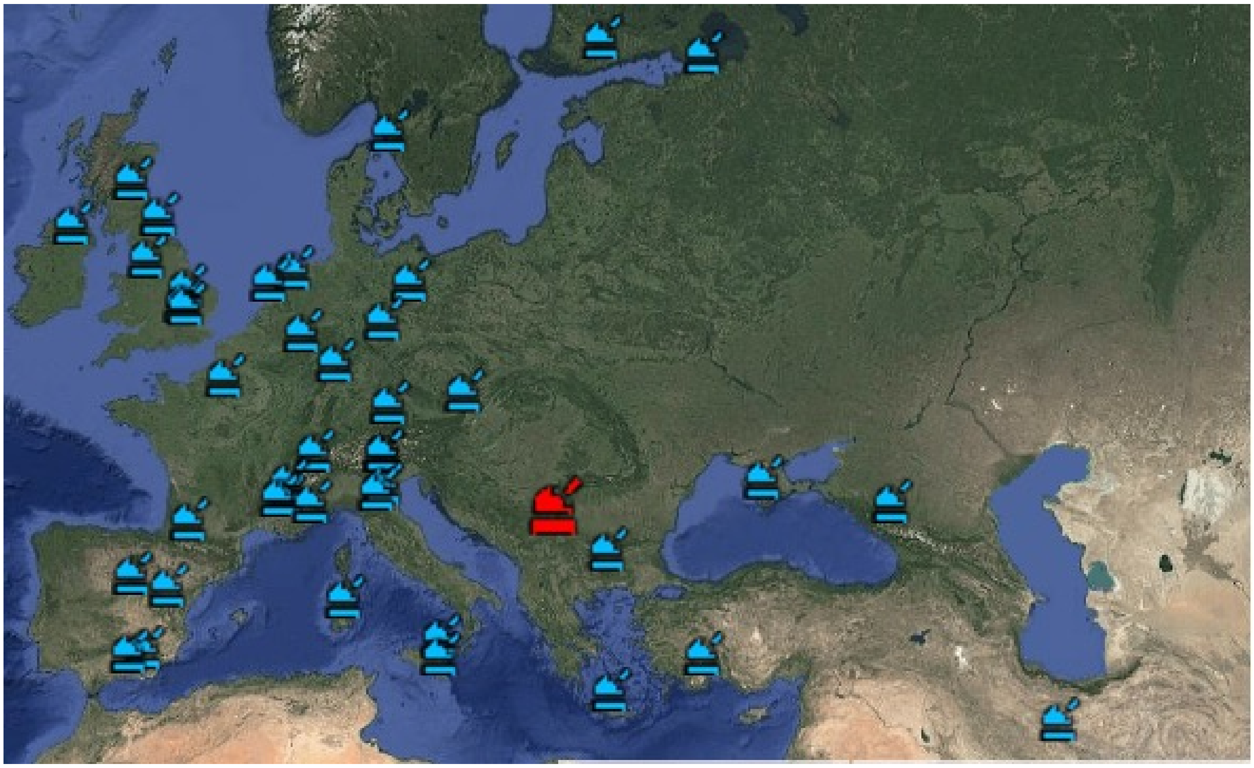


Figure 1: Vidojevica Station Coordinates: Longitude: 21° 33' 20.4" ; Latitude: 43° 08' 24.6" ; Elevation: 1150m

Observation Dates:

- Night 1: 29.11.2024
- Night 2: 30.11.2024

Telescope:

1.4m Milanković Telescope at AS Vidojevica

Filters:

- Narrow-band: Hα, [SII]
- Broad-band: R

Target Information:

- Name: Pa30 (SN1181)
- Object Type: Galactic supernova remnant (SNR)
- Estimated Visual Magnitude: $\sim$14.5
- Coordinates (Epoch J2000.0): 02:05:37.04, +64:49:42

Challenges:

Although Supernova Remnant (SNR) resides in our own galaxy, its high visual magnitude indicates that it is relatively faint, which may present observational challenges.

Workflow:

i. **Prepare an object log table** including key information for each target: name, object type, visual magnitude and coordinates obtained from the SIMBAD database. Use the standard epoch J2000.0, and verify coordinates by testing SIMBAD search queries for the observation epoch.

ii. **Check object visibility** for the selected observation dates and the AS Vidojevica location using tools such as the Staralt program or the Airmass tool.

iii. **Select suitable targets** based on visibility results, and create a detailed observation plan for the specified nights. Generate visibility maps for the selected objects only.

iv. **Prepare finding charts** that show the target and nearby comparison or standard stars in the same field of view. Recommended tools for this task include SAO-DSS and the SAOImage DS9 visualization software.

v. **Estimate exposure times** for each target using custom Python code developed for the AS Vidojevica site, or reference external tools such as the LCO Exposure Time Calculator.

vi. **Generate a telescope input table** for the selected targets. Each row should include the object name, RA, and Dec in the J2000.0 epoch (e.g., 06:52:12 +74:25:37).

1.1.1 Object Log Table Preparation

First, we will prepare an object log table that includes essential information for each target. The table would contain the following columns: object name, type, visual magnitude, and coordinates (RA and Dec) obtained from the SIMBAD astronomical database. Using the standard epoch J2000.0 for consistency, we will perform test queries in SIMBAD to verify the coordinates and ensure they align with the intended observation epoch.

Name	Object type	Visual Magnitude	RA	Dec
SNR G130.7+03.1 (Pa 30)	SNR	14.5	02 05 37.0	+64 49 42

From the above table, we can see that Pa30's visual magnitude is 14.5, indicating that it is a relatively faint object. It would not be visible to the naked eye and thus requires a telescope for successful observation. The following factors should be considered to ensure optimal visibility:

i. **Telescope Aperture:** A telescope with a sufficiently large aperture, such as the 1.4m Milanković Telescope, is capable of detecting this object.

ii. **Sky Conditions:** Observing under dark skies with minimal light pollution is essential for detecting faint sources like Pa30.

iii. **Exposure Time:** Longer exposure times are necessary to collect enough photons from high-magnitude (i.e., faint) objects to produce usable images.

1.1.2 Visibility Analysis

The visibility of Pa30 for the nights of 29.11 and 30.11.2024 was analyzed using the Airmass.org and Staralt. The results are summarized below:

Date	Start Time (UTC)	End Time (UTC)	Altitude Range (°)	Airmass
29.11.2024	15:21	22:19	35°–75°	1.1–1.9
30.11.2024	16:13	25:38	35°–80°	1.0–1.8

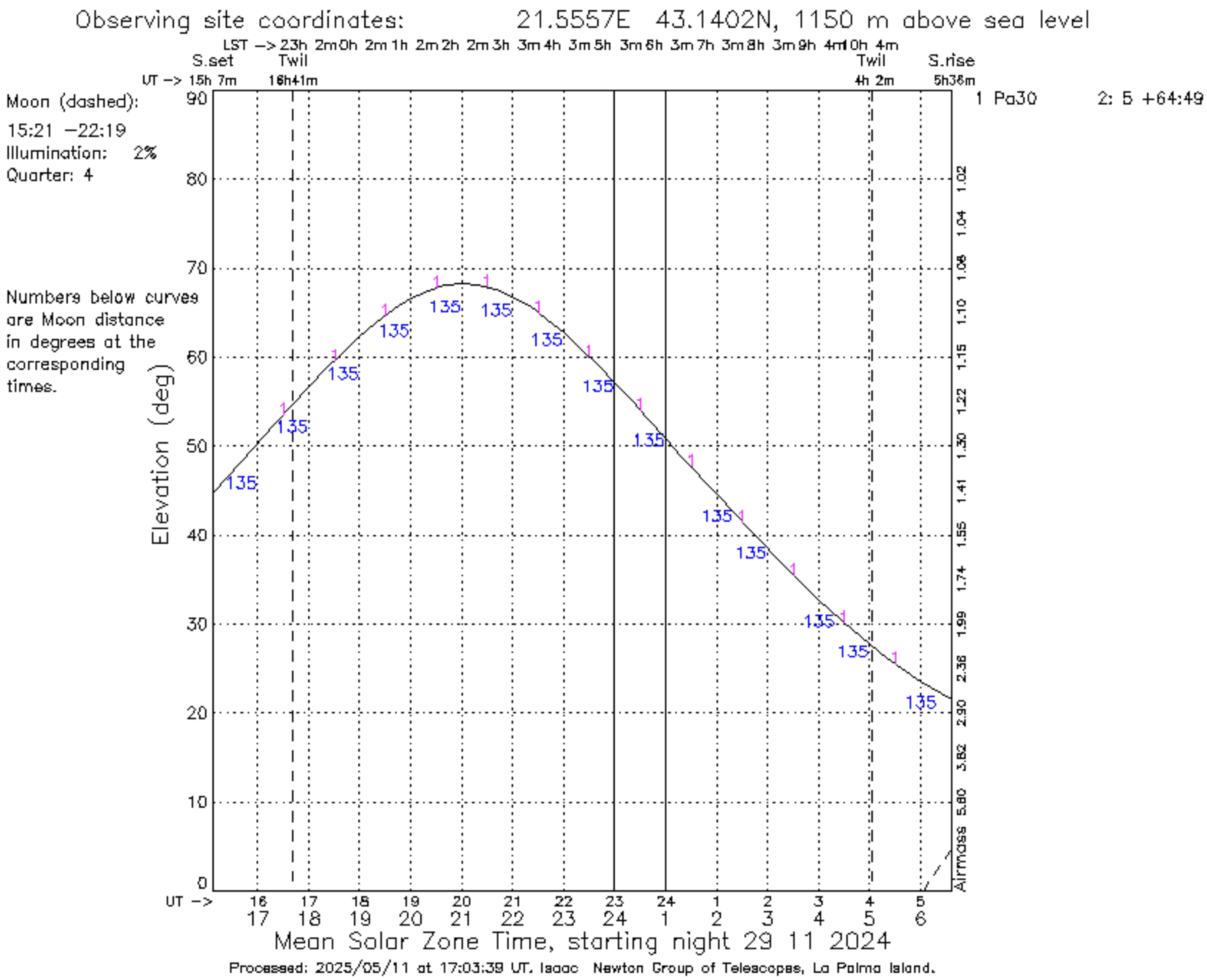


Figure 2: Night 1: 29.11.2024

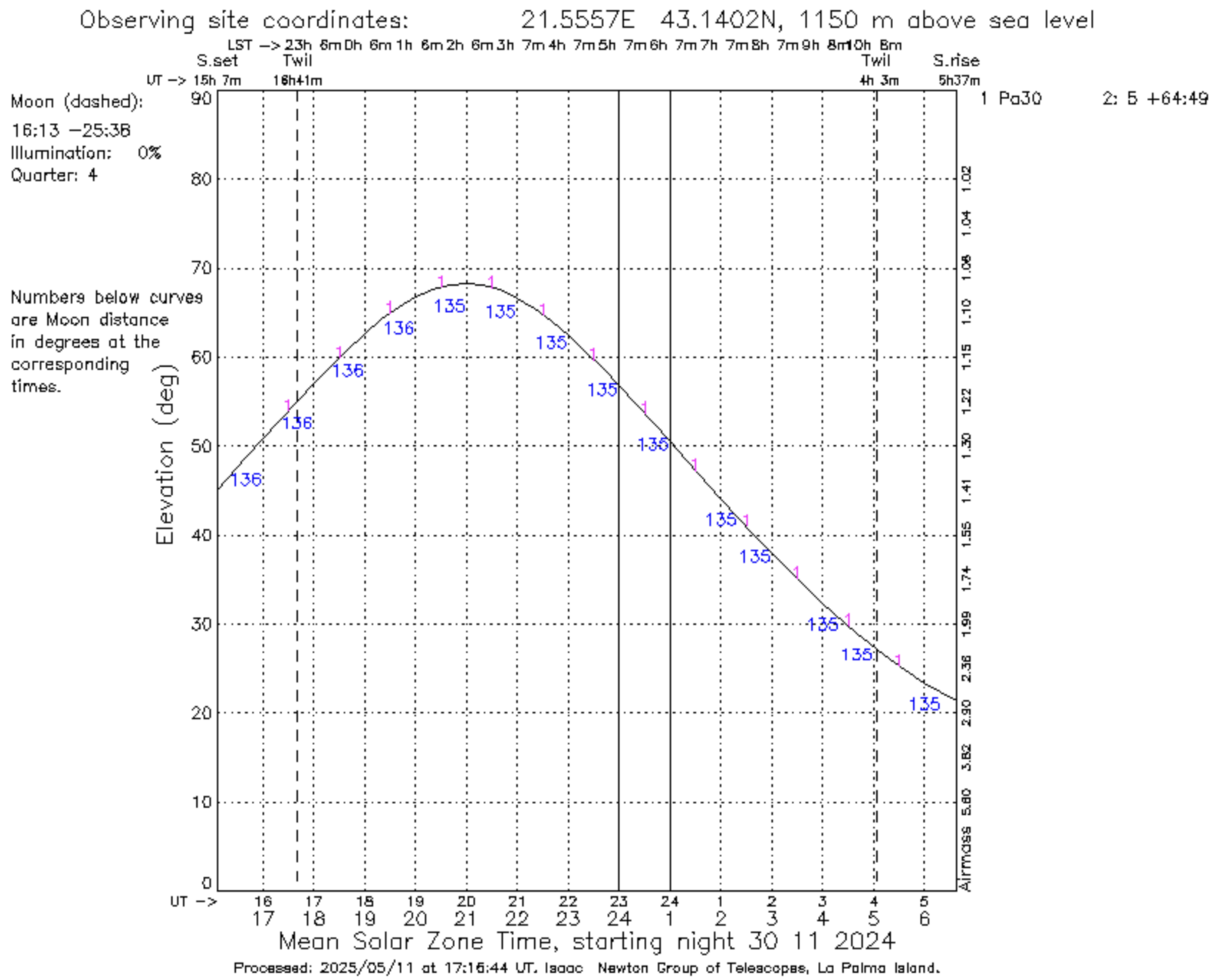


Figure 3: Night2: 30.11..2024

Establishing the Observation Time Frame

To define the optimal observational window, we first converted the geographic coordinates of the Astronomical Station Vidojevica into decimal degrees using an online coordinate conversion tool. The station's position is summarized below:

Coordinate	DMS Format	Decimal Degrees
Longitude	21° 33′ 20.4″ E	21.555667
Latitude	43° 08′ 24.6″ N	43.140167

Using these coordinates, the start and end times of astronomical twilight were determined for each of the planned observing nights. These intervals, shown in Table **??**, define the darkest periods of the night, free from significant twilight interference, and thus represent the most favorable time frame for conducting observations.

Date	**Twilight Start**	**Twilight End**
29 November 2024	05:03	17:42
30 November 2024	05:03	17:41

These twilight boundaries provide the basis for scheduling observations during the darkest and most stable atmospheric conditions.

Night Schedule – Friday, 29 November 2024:

Time (Local)	**Object / Activity**	**notes**
16:00 – 17:00	Bias, dark, flats	Perform evening calibration
17:00 – 18:00	SNR G130.7+03.1 (Pa30)	High elevation, early visibility

Night Schedule – Saturday, 30 November 2024:

Time (Local)	**Object / Activity**	**notes**
16:00 – 17:00	Bias, dark, flats	Perform evening calibration
17:00 – 19:00	SNR G130.7+03.1 (Pa30)	Duplicate – in case conditions are not suitable on 29 Nov

1.1.3 Finding Charts and Field-of-View Estimation

Task Overview

The objective is to prepare finding charts for selected targets, clearly marking the object and suitable comparison or standard stars within the same field of view (FOV). Tools such as **SAO-DSS**, **Aladin**, and **SAOImage DS9** are used to generate these charts.

Instrument Setup and FOV Calculation

To estimate the effective field of view, we consider the specifications of the **Andor iKon-L 936 CCD** camera installed at **port 1** of the **1.4m Milanković Telescope**, optimized for scientific imaging. This port is equipped with a **0.65× focal reducer**, giving an effective focal length of **7132 mm**, and a **field flattener (f/7.6)**, corresponding to a final focal length of $\mathbf{F = 10.64\ m}$.

CCD Camera Specifications:

- Sensor: 2048 × 2048 pixels

- Pixel size: 13.5 μm × 13.5 μm
- Sensor area: 27.6 mm × 27.6 mm
- Cooling: Down to –100°C
- Quantum Efficiency (QE): >90% (back-illuminated)
- Read noise: ∼2.9 e^-
- Filters: Johnson B, V, R, I, L; narrow-band Hα, Hα continuum, and [SII]

This configuration is well-suited for deep imaging of faint targets using both broad- and narrow-band filters.

Plate Scale Calculation

To compute the plate scale P in arcseconds per pixel, we use the following formula:

$$P[\text{arcsec/pixel}] = \frac{206265 \times k}{f}$$

Where:

- $k = 13.5\,\mu\text{m}$ is the pixel size
- $f = 10.64\,\text{m} = 10640\,\text{mm}$ is the effective focal length

$$P = \frac{206265 \times 13.5}{10640 \times 1000} \approx 0.2617\,\text{arcsec/pixel}$$

Field of View (FOV) Calculation

Using the number of active pixels (2048 × 2048), we compute the total angular FOV:

$$FOV = P \times 2048 = 0.2617 \times 2048 \approx 535.98\,\text{arcsec} \approx 8.93\,\text{arcmin}$$

Thus, the instrument provides an approximate **9 × 9 arcmin** field of view.

1.1.4 Finding Charts for Pa30

For each target, standard and comparison stars are selected from the catalog of **Doroshenko et al. (2005)** [1]. To ensure they fall within the 9 × 9 FOV, their angular separation from the target is verified using the Airmass.org tool [2]. Only stars within the FOV are included. Each star is identified using the **CS codes** assigned in Doroshenko et al. (2005). Physical and photometric properties of the selected stars are referenced from the same study.

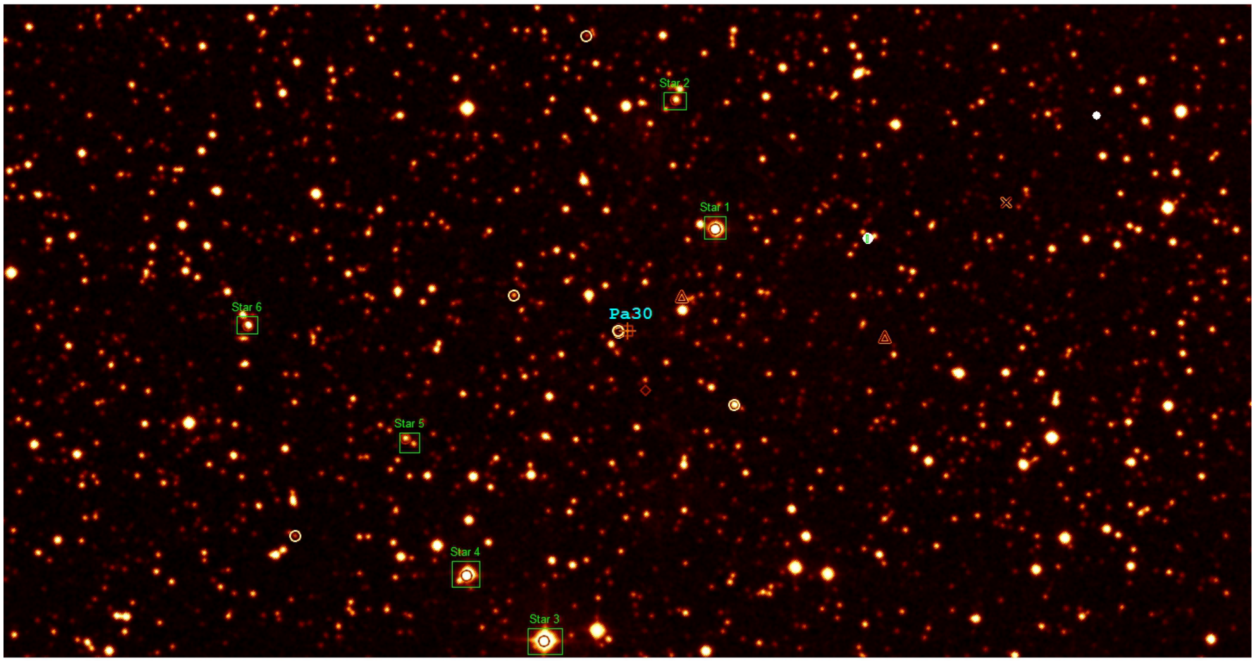


Figure 4: Finding chart for Pa30

2 Bright Type 1 AGNs

This focuses on observing a sample of bright Type 1 Active Galactic Nuclei (AGNs) using broad-band (B, V, R) and narrow-band (H$\alpha, [SII], Continuum) filters.$

2.1 Object Log Table

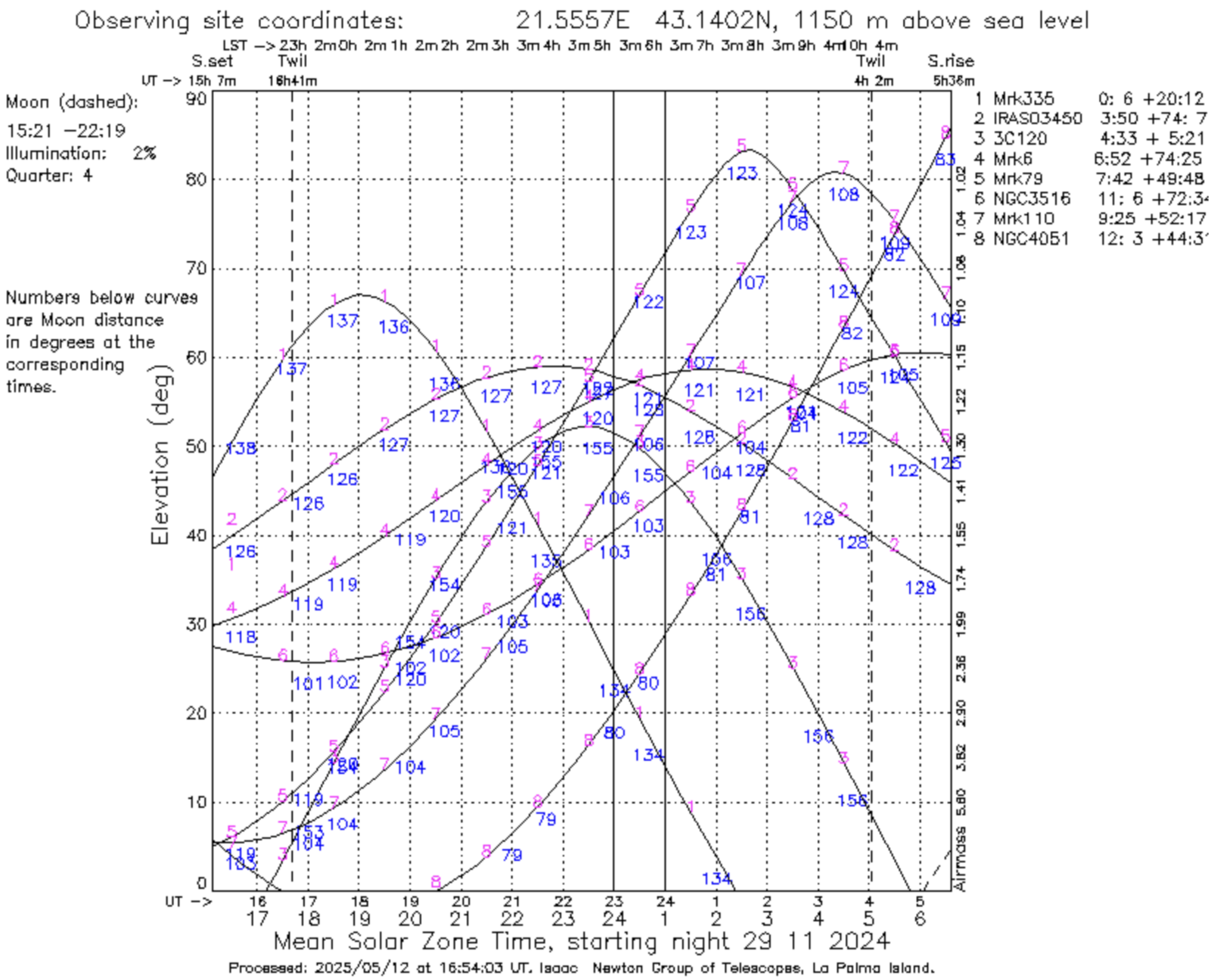
The following table summarizes the basic properties of the selected AGNs, retrieved from the SIMBAD database.

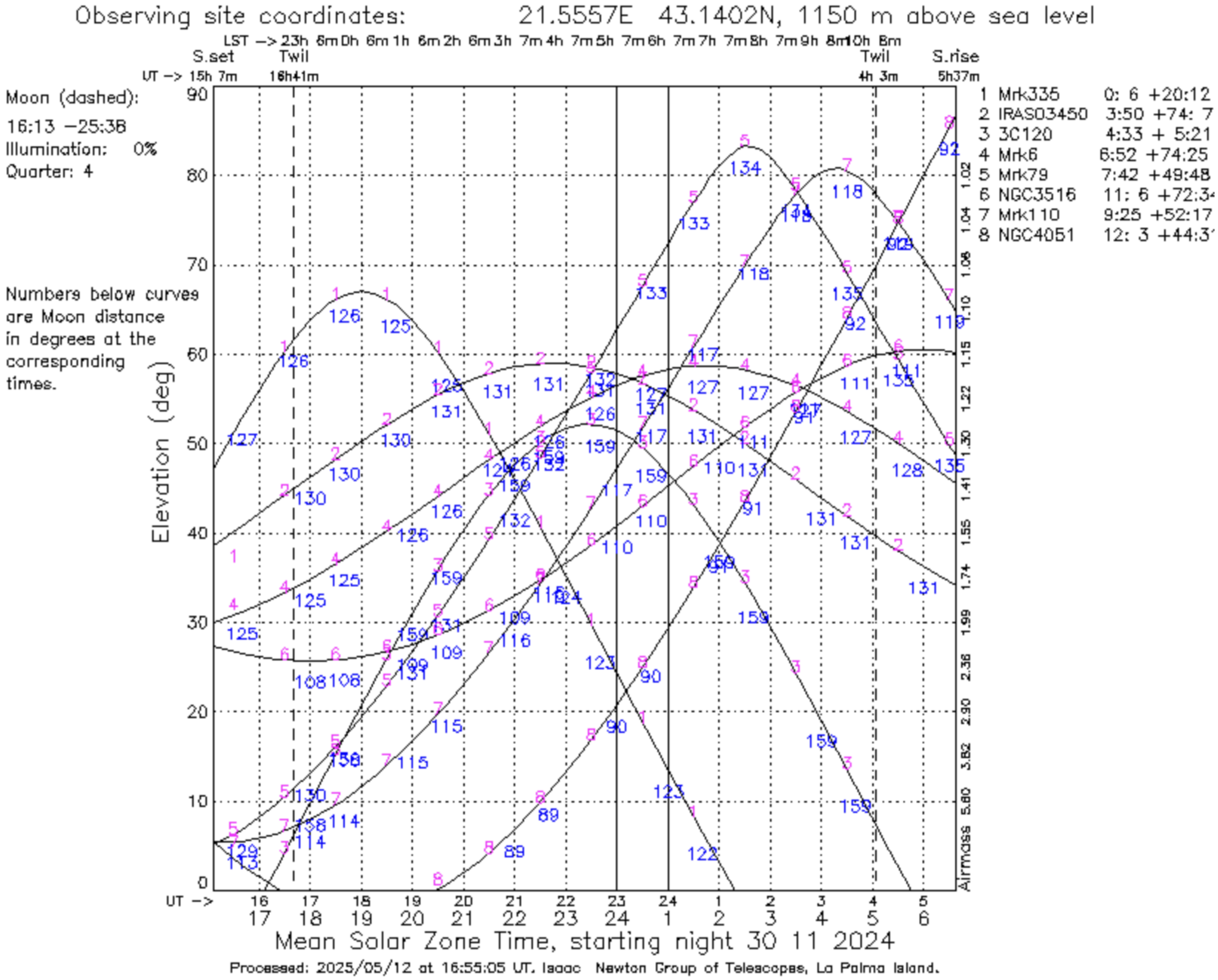
Table 1: Basic properties of selected AGNs

Name	**V Magnitude**	**RA (J2000.0)**	**Dec (J2000.0)**
Mrk335	13.9	00:06:19.5	+20:12:10
IRAS03450	14.1	03:50:50.8	+74:07:47
3C120	13.0	04:33:11.0	+05:21:16
Mrk6	13.6	06:52:12.3	+74:25:37
Mrk79	13.4	07:42:32.8	+49:48:35
Mrk110	16.41	09:25:12.8	+52:17:10
NGC3516	12.5	11:06:47.5	+72:34:07
Mrk279	14.46	13:53:03.4	+69:18:29
NGC3227	11.79	10:23:30.6	+19:51:54
NGC4051	12.9	12:03:09.6	+44:31:53

2.1 Visibility Analysis

Check the visibility of all selected targets for the specified observation dates and the location of AS Vidojevica using tools such as the Staralt program or Airmass.org. The visibility of the selected AGNs was analyzed for the nights of 29.11 and 30.11.2024. The results are summarized below:


Observing site coordinates: 21.5557E 43.1402N, 1150 m above sea level
Moon (dashed):
15:21 −22:19
Illumination: 2%
Quarter: 4
Numbers below curves are Moon distance in degrees at the corresponding times.
S.set
UT -> 15h 7m
Twil
16h41m
Twil
4h 2m
S.rise
5h36m
1 Mrk335 0: 6 +20:12
2 IRAS03450 3:50 +74: 7
3 3C120 4:33 + 5:21
4 Mrk6 6:52 +74:25
5 Mrk79 7:42 +49:48
6 NGC3516 11: 6 +72:34
7 Mrk110 9:25 +52:17
8 NGC4051 12: 3 +44:31
Elevation (deg)
Airmass
Mean Solar Zone Time, starting night 29 11 2024
Processed: 2025/05/12 at 16:54:03 UT. Isaac Newton Group of Telescopes, La Palma Island.



2.2 Establishing the Time Frame for Type 1 AGN

To define the optimal observational window, we first converted the geographic coordinates of the Astronomical Station Vidojevica into decimal degrees using an online coordinate conversion tool. The station's position is summarized below:

Night Schedule for 29th November 2024

Local Time	Object	Notes
16:00 – 17:00	Bias, dark, flats	Perform evening calibration
18:00 – 19:00	2. Mrk335	High elevation, early visibility
19:00 – 21:00	5. Mrk6 (IC 450)	
21:00 – 23:00	6. Mrk79	
23:00 – 00:30	8. NGC3516	
00:30 – 02:00	7. Mrk110	
02:00 – 03:30	10. NGC3227	
03:30 – 05:00	11. Mrk817	
05:00 – 06:00	Bias, dark, flats	Perform morning calibration

Night Schedule for 30th November 2024

Local Time	Object	Notes
16:00 – 17:00	Bias, dark, flats	Perform evening calibration
19:00 – 22:30	2. Mrk335	Duplicate – in case conditions are not suitable on 29 Nov
22:30 – 00:30	4. 3C120 (Mrk 1506)	
00:30 – 01:30	3. IRAS 03450+0055	
01:30 – 02:30	7. Mrk110	Duplicate – in case conditions are not suitable on 29 Nov
02:45 – 04:00	9. Mrk279 and 12. NGC4151	
03:45 – 04:45	11. NGC4051	
05:00 – 06:00	Bias, dark, flats	Perform morning calibration

2.3 Finding Chart for Type 1 AGNs

The same methodology and criteria described above have been applied in preparing the finding charts for the Bright Type 1 AGNs. For each AGN target, standard and comparison stars were selected from the catalog of **Doroshenko et al. (2005)** [1]. To ensure they fall within the 9 $\times$ 9 field of view (FOV), their angular separations from the respective targets were verified using the Airmass.org tool [2]. Only those stars located within the instrument's FOV were included. Each selected star is labeled according to the CS codes assigned in Doroshenko et al. (2005) [1], and their physical and photometric properties are referenced from the same study.

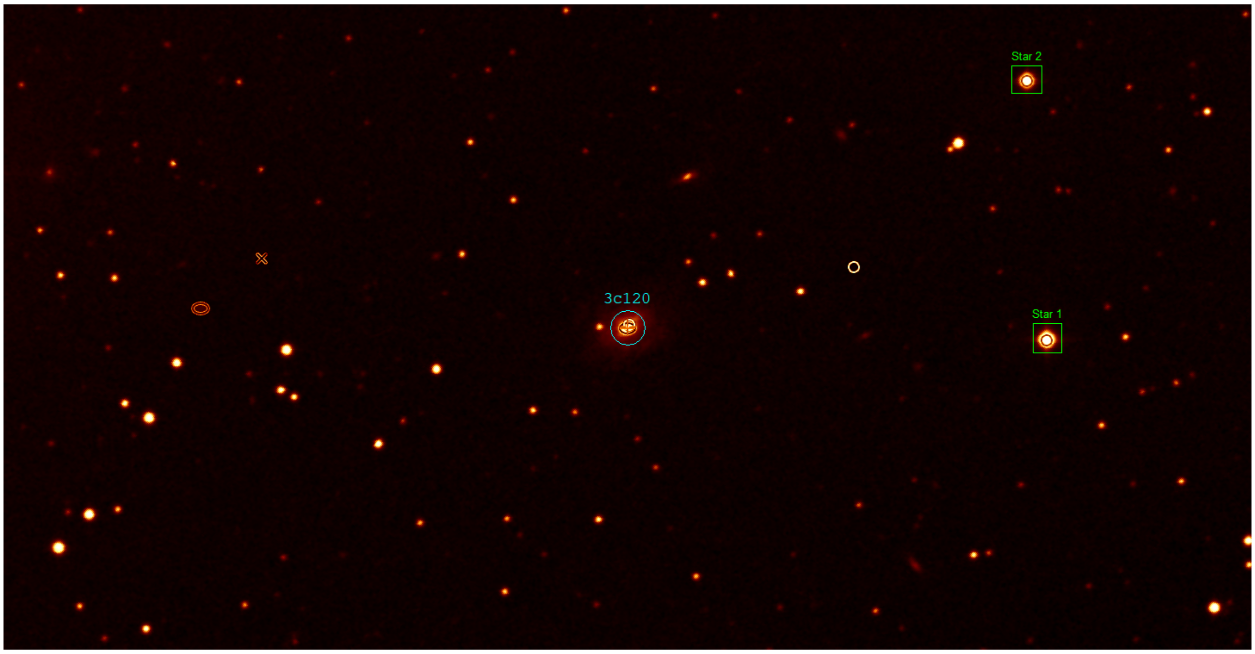


Figure 5: Finding chart for 3C120

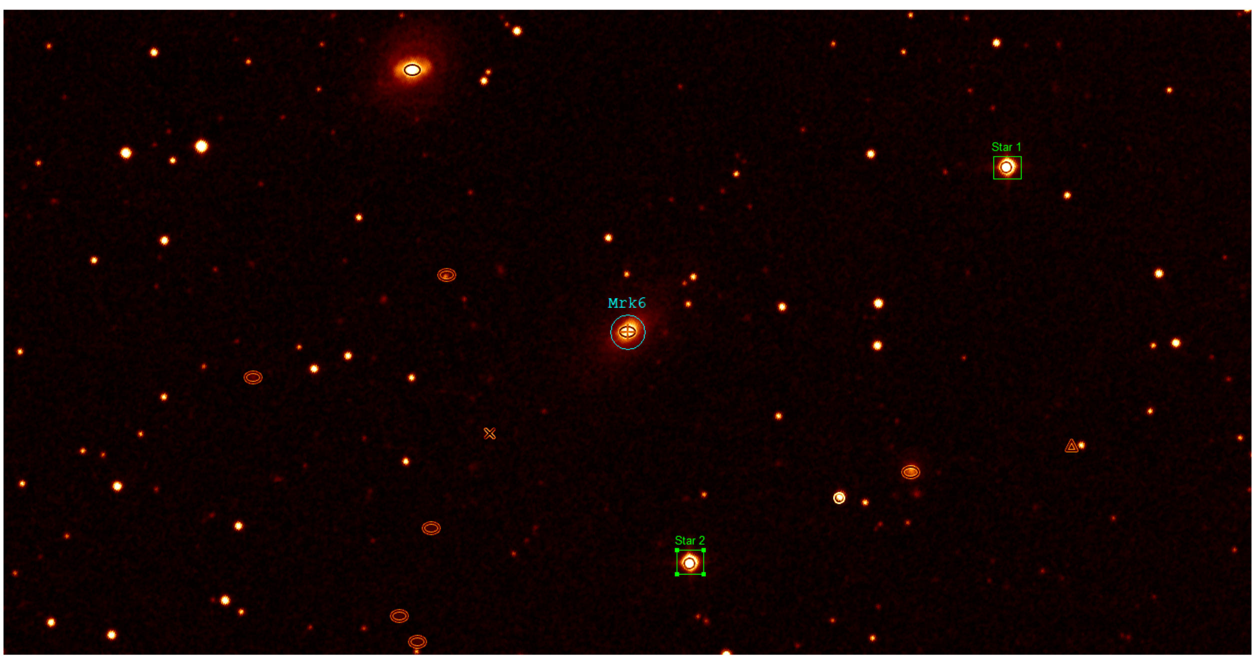


Figure 6: Finding chart for Mrk6

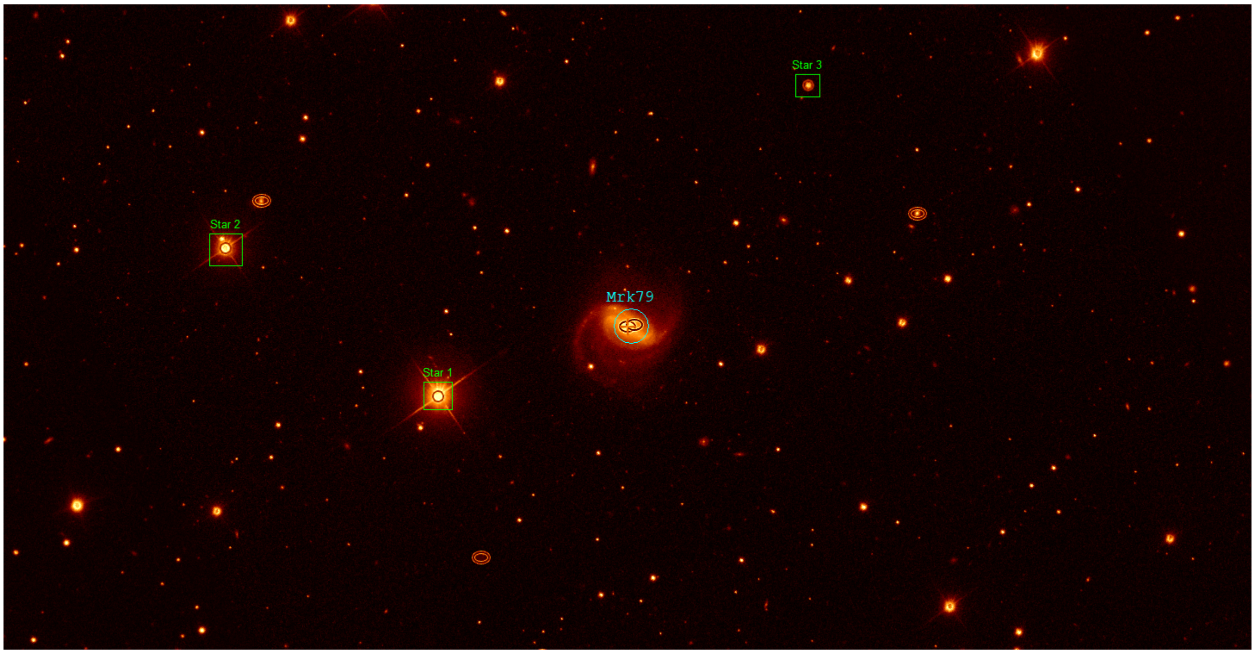


Figure 7: Finding chart for Mrk79

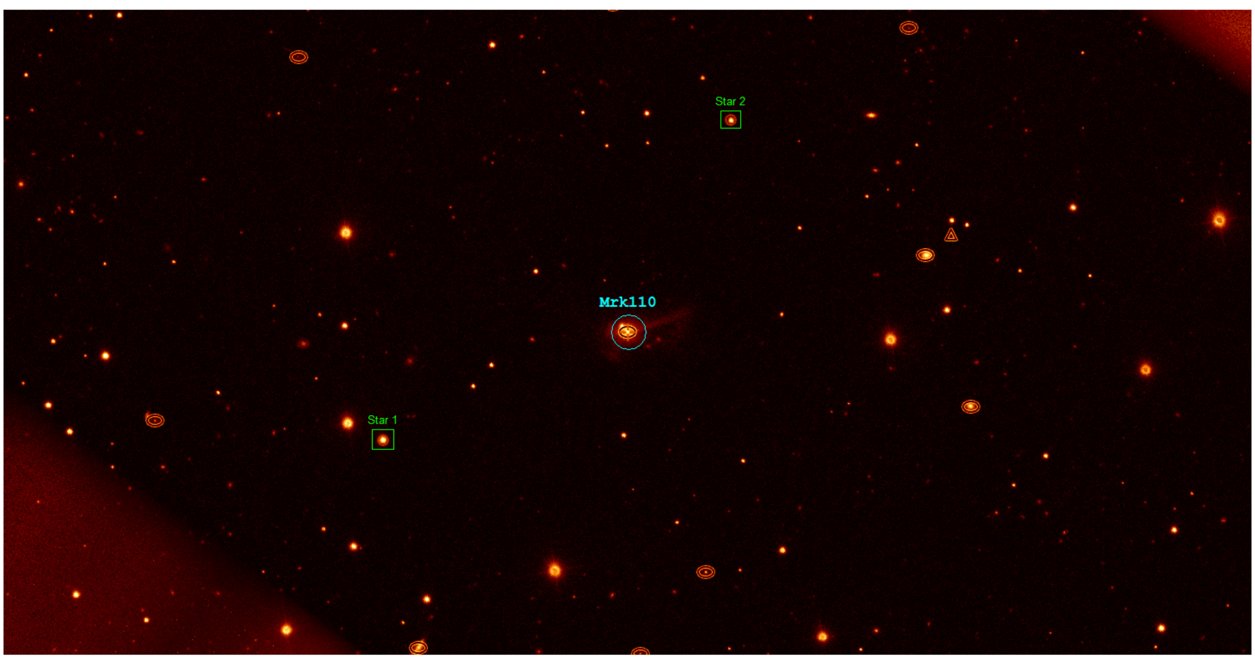


Figure 8: Finding chart for Mrk110

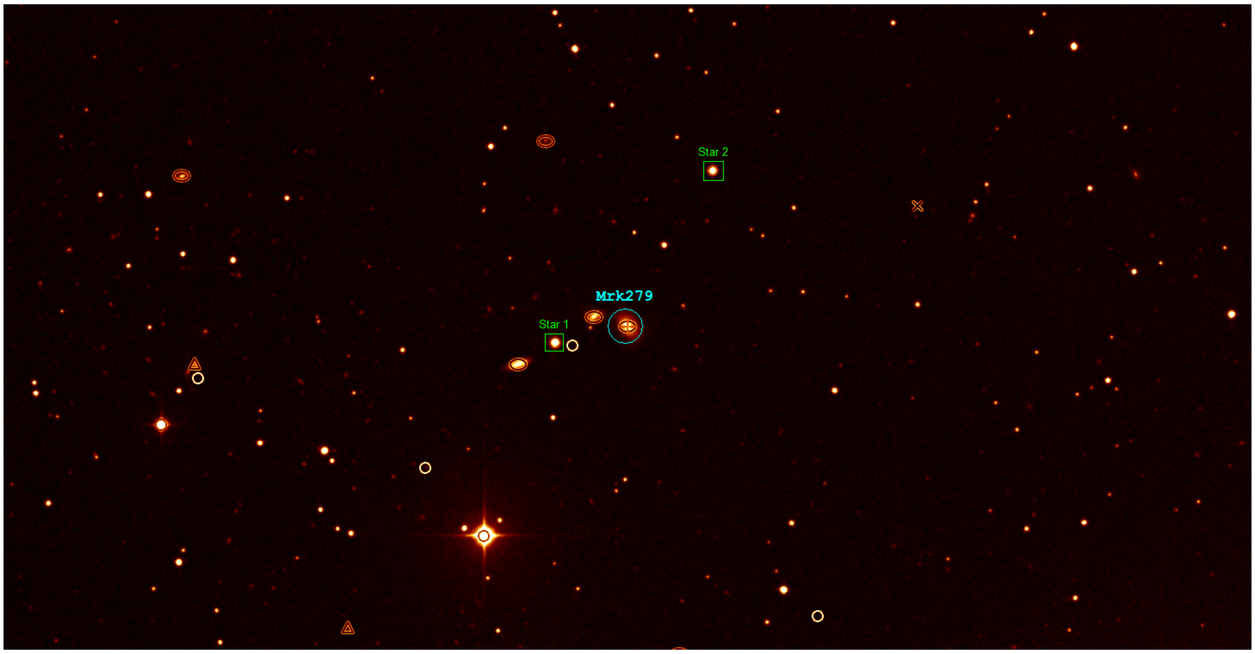


Figure 9: Finding chart for Mrk279

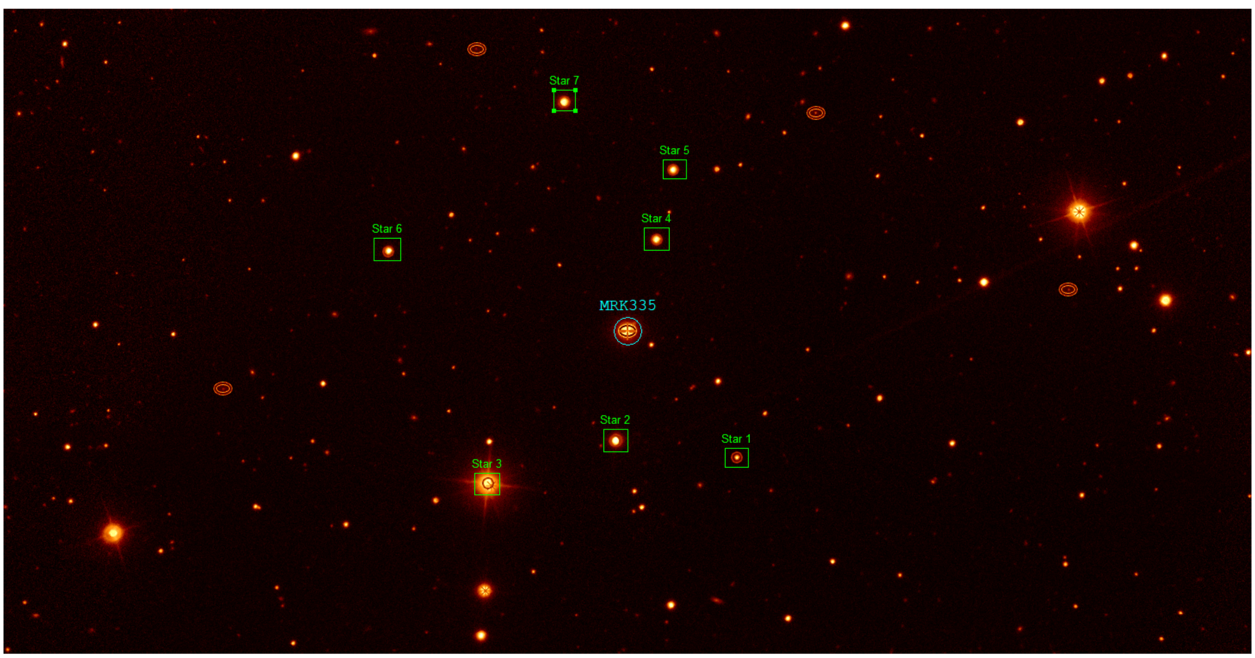


Figure 10: Finding chart for Mrk335

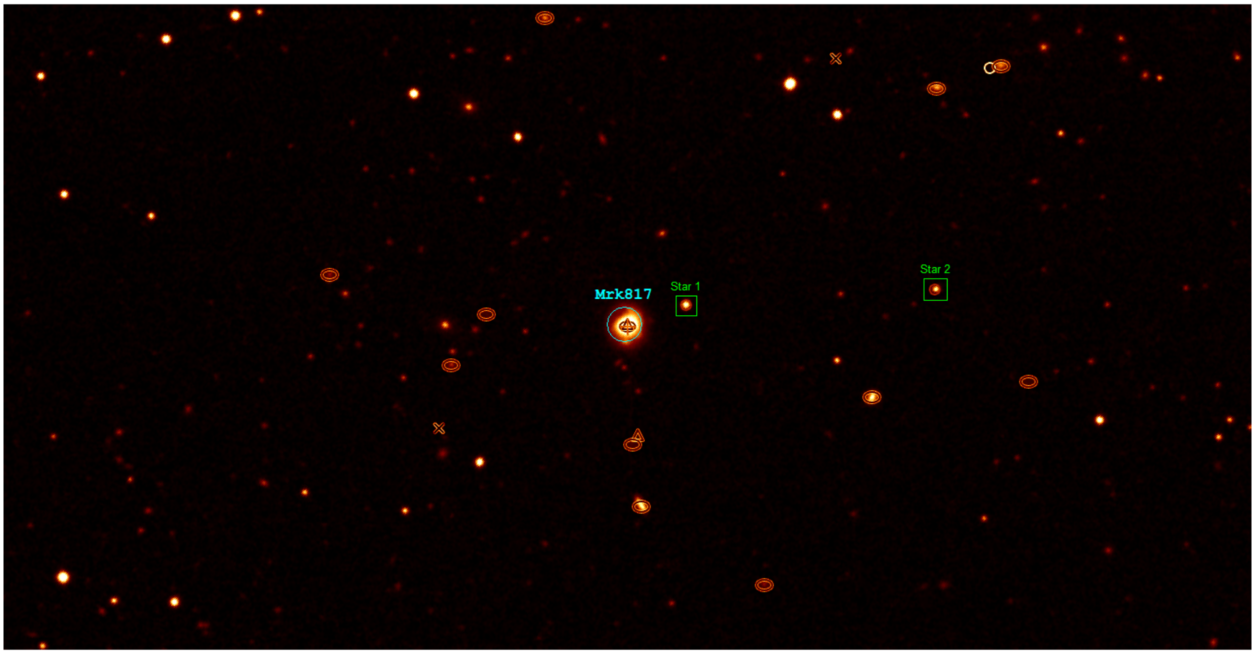


Figure 11: Finding chart for Mrk817

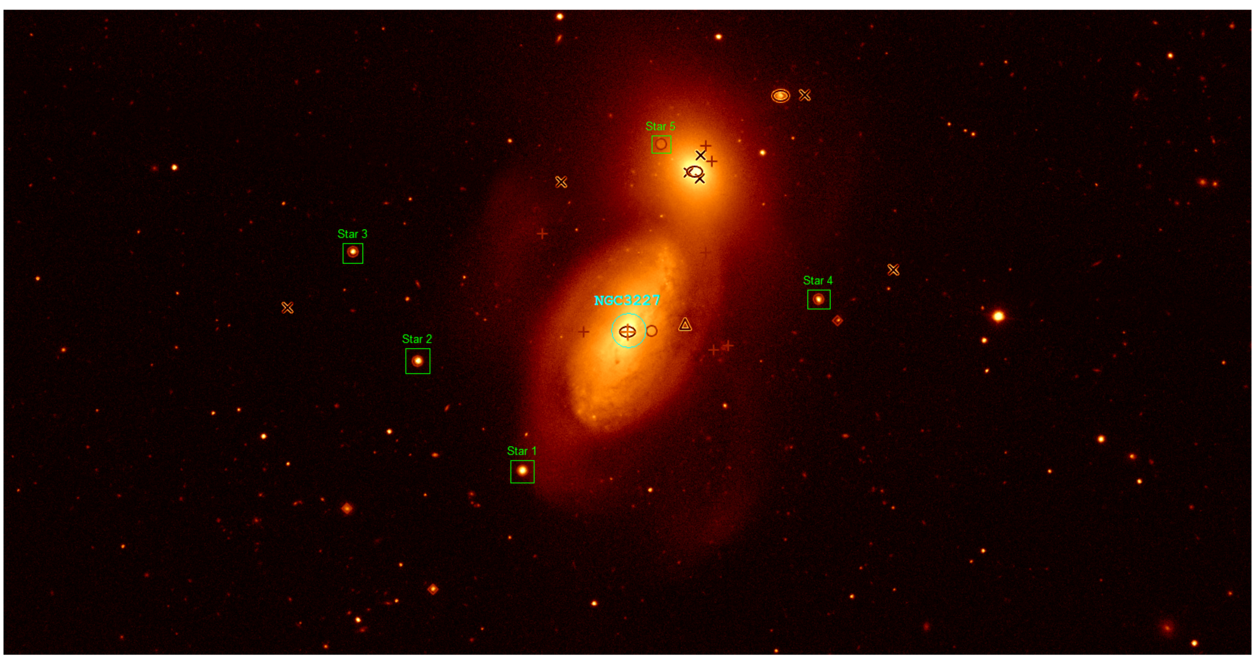


Figure 12: Finding chart for NGC3227

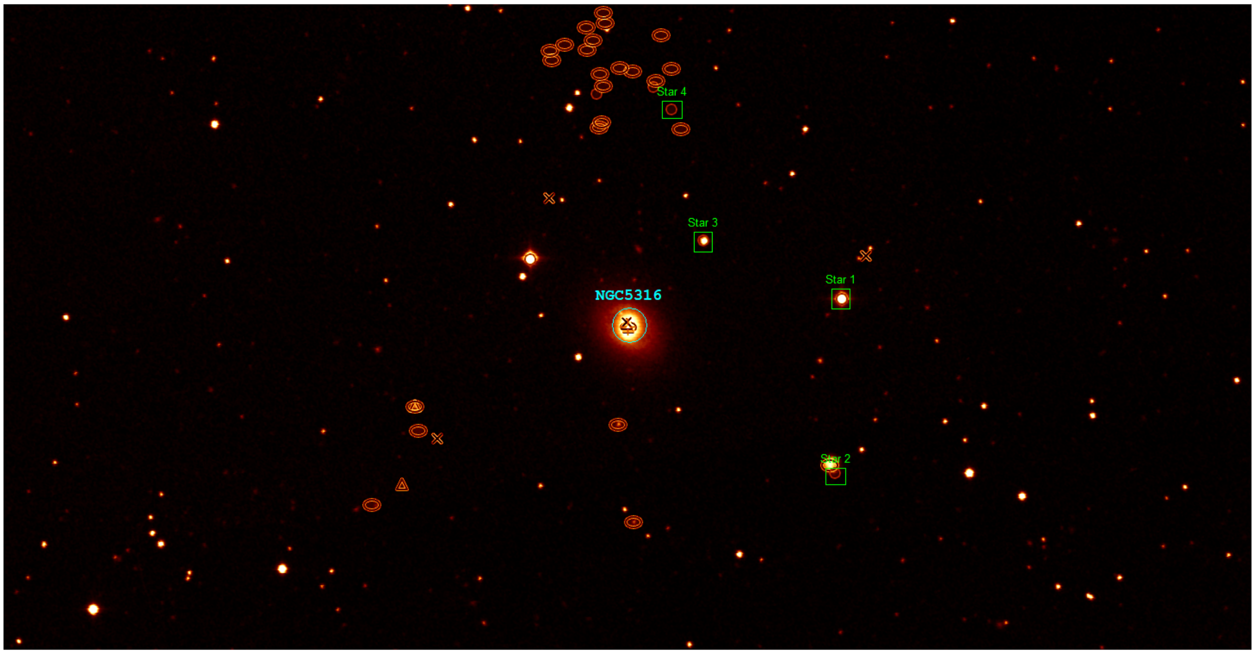


Figure 13: Finding chart for NGC3516

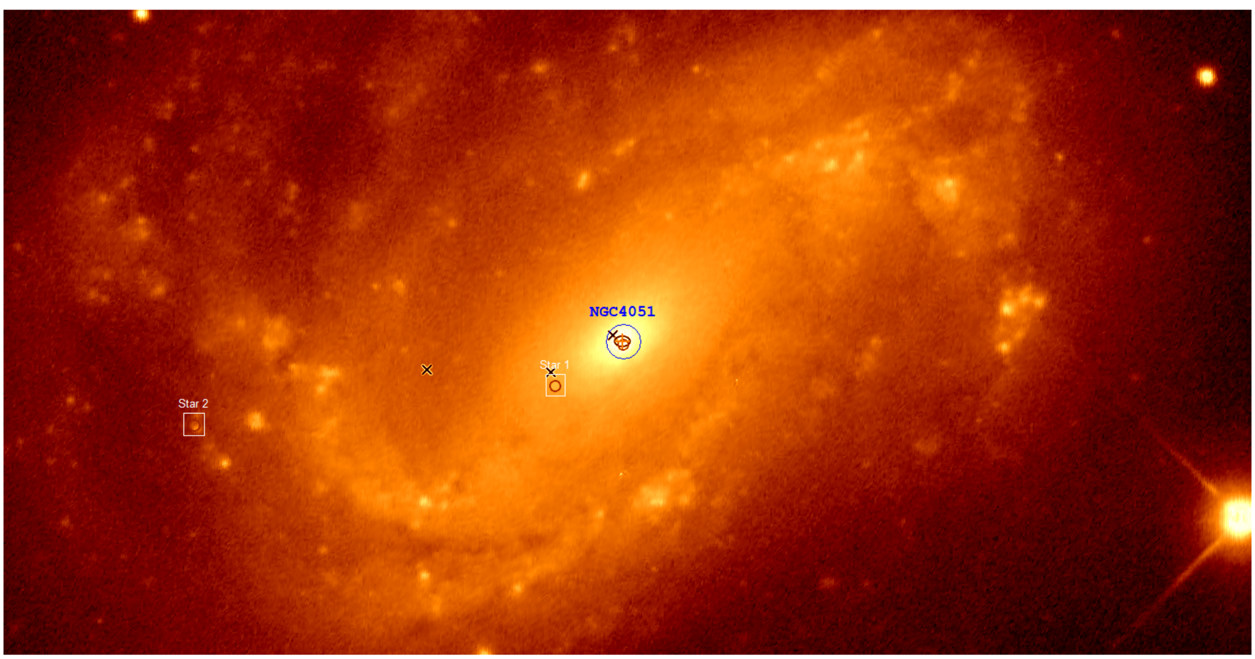
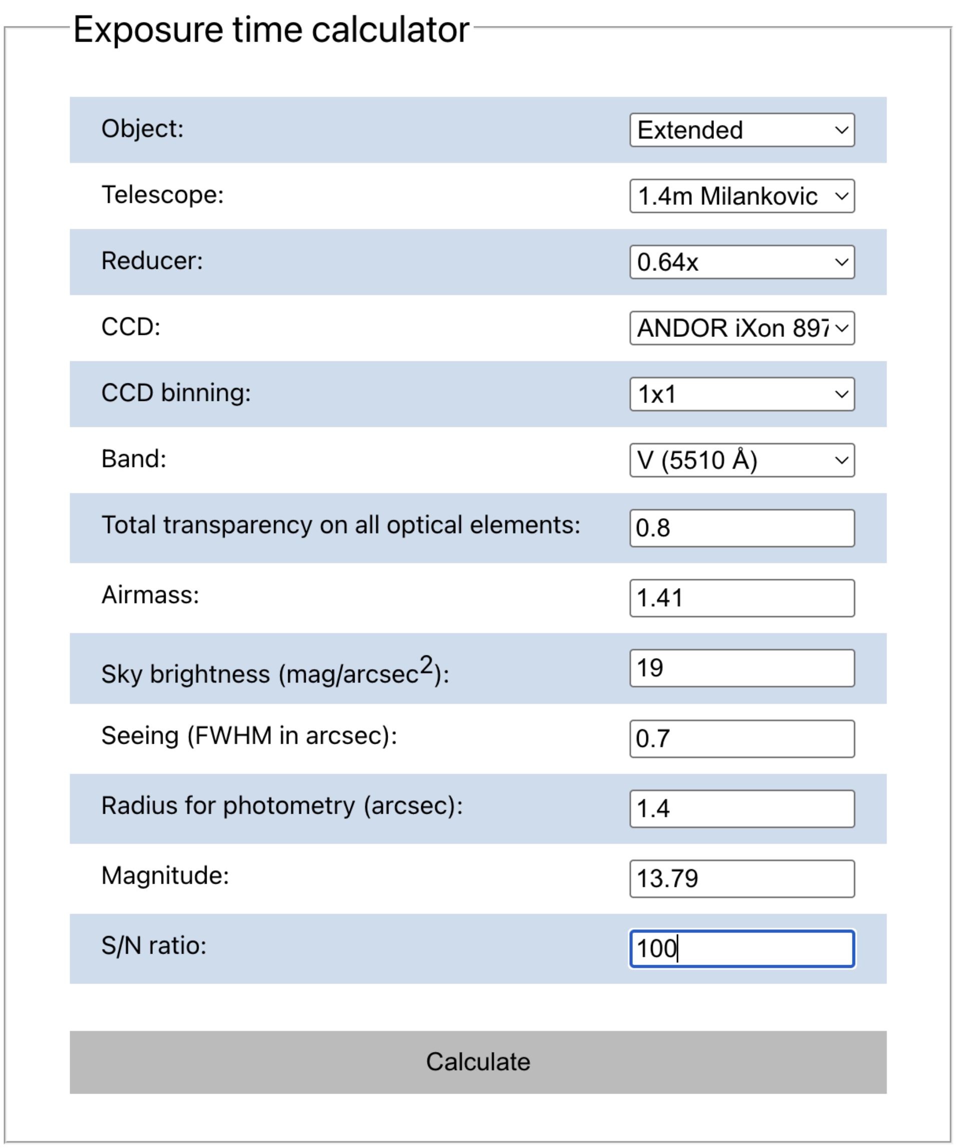


Figure 14: Finding chart for NGC4051

2.4 Combined Exposure Time Calculations

The exposure time is estimated using a custom-developed Python script tailored for observations at AS Vidojevica. Additionally, the exposure time calculator tool available at [3] is used as a reference for cross-validation.



Estimated exposure times for selected AGN and SNR targets

Name	M_V	Airmass	Exposure Time (s)	Point/Extended
SNR G130.7+03.1 (Pa 30)	15.4	1.22	2.07	Point
Mrk335	13.85	1.10	0.41	Point
IRAS 03450+0055	14.64	1.55	0.98	Point
3C120 (Mrk 1506)	15.05	1.30	1.44	Point
Mrk6 (IC 450)	14.19	1.41	0.61	Point
Mrk79	14.27	1.55	3.98	Extended
Mrk110	16.41	1.10	6.73	Point
NGC3516	12.40	1.55	0.70	Extended
Mrk279	14.46	1.41	0.79	Point
NGC3227	11.79	1.30	0.38	Extended
NGC4051	12.92	1.15	1.05	Extended
NGC4151	11.48	1.15	0.28	Extended
Mrk817	13.79	1.41	2.47	Point

2.5 Telescope Input Table

For the selected objects, a telescope input table will be prepared including the target name and its equatorial coordinates in Right Ascension (RA) and Declination (Dec), specified in the J2000.0 epoch. The coordinates will follow the standard format, for example: `06:52:12 +74:25:37`.

Telescope Input Table with J2000.0 Coordinates

Name	RA (ICRS, J2000.0)	Dec (ICRS, J2000.0)
SNR G130.7+03.1 (Pa 30)	02:05:37	+64:49:42
Mrk335	00:06:20	+20:12:11
IRAS 03450+0055	03:47:40	+01:05:14
3C120 (Mrk 1506)	04:33:11	+05:21:16
Mrk6 (IC 450)	06:52:12	+74:25:37
Mrk79	07:42:33	+49:48:35
Mrk110	09:25:13	+52:17:10
NGC3516	11:06:47	+72:34:07
Mrk279	13:53:03	+69:18:29
NGC3227	10:23:31	+19:51:54
NGC4051	12:03:10	+44:31:53
NGC4151	12:10:33	+39:24:21
Mrk817	14:36:22	+58:47:39

1.6 Expected Outcome

- High-resolution imaging of both SNR and AGN
- Structural and chemical characterization
- Complementary broad-band data for analysis

1.7 Conclusion

This proposal presents a detailed plan to observe Galactic SNR and bright type AGN using the Milanković Telescope. Careful planning and optimal observing conditions will ensure high-quality data for the study of this supernova remnant and AGNs.

Tools and Catalogues

The following tools and catalogues were used to plan and optimize the observing proposal:

i. **SIMBAD** – Object search.
https://simbad.u-strasbg.fr/simbad/sim-fbasic

ii. **Staralt** – Object visibility tool.
http://catserver.ing.iac.es/staralt/

iii. **Airmass** – Interactive object visibility.
https://airmass.org/?redir=y

iv. **Astronomical Station Vidojevica** – Site and instrumentation details.
https://vidojevica.aob.rs
Instruments Page

v. **Exposure Time Estimation** – Using the LCO calculator and custom Python code tailored for AS Vidojevica.
https://lco.global/education/observing/exposure-time-estimating/

References

[1] V. T. Doroshenko, S. G. Sergeev, V. I. Pronik, N. G. Merkulova, and A. V. Sergeeva, "Optical monitoring of active galactic nuclei: selection and calibration of comparison stars," *Astronomy Reports*, vol. 49, no. 8, pp. 573–581, 2005.

[2] Airmass.org. Online visibility calculator. Available at: `https://airmass.org` (Accessed 2024).

[3] Las Cumbres Observatory. Exposure Time Calculator. Available at: `https://lco.global/education/observing/exposure-time-estimating/` (Accessed 2024).