Complete Tutorial – Observations with SPARC4

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General Information

Observation Nights:

May 6–9, 2024, *4 nights:* Gabriel Pampolha and Natan de Isídio.

June 6–9, 2024, *4 nights:* Maria Clara Siviero, Gabriel Pampolha, and Juan Maldonado.
Logsheets: 6JUN2024, 7JUN2024, 8JUN2024, 9JUN
Staralt: JUN/2024

April 27–30, 2025, *4 nights:* Maria Clara Siviero, Gabriel Pampolha, Juan Maldonado, and Thiago Bueno.
Logsheets: 27APR2025, 28APR2025, 29APR2025, 30APR2025
Staralt: APRIL/2025
Finders: April 2025

July 23–26, 2025, *4 nights:* Maria Clara Siviero, Juan Maldonado, Thiago Bueno, and Roberta Costa
Logsheets: 23JUL2025, 24JUL2025, 25JUL2025, 26JUL2025
Staralt: JUL/2025
Finders: July 2025

Useful Links

- OPD Weather Conditions
- Tutorial Video – June 9
- SPARC4 Observer Guide
- Flat Time Table
- SPARC4 Pipeline
- VPN Access for OPD Remote Observations
- OPD Schedule

Computers

1. **Centaurus**:
   - Terminal with three windows:
     - Image display in IRAF
     - Focus pipeline execution
     - Continuous data backup
2. **S4GUI**:
   - S4GUI. Settings: object name, suffix, exposure time/number
   - **Guider Setup**
3. **Auto Guider**:
   - Autoguider: Guiding system
   - **Aladin**
4. **TCSPD**:
   - Telescope control:
     - Calibrations (`bias`, `flat`, `focus`)
     - Dome management
     - Pointing adjustments

1 Remote Access to Computers

1.1 VPN Access

1. Observation via web browser:
   - Through the OPD access site: https://fortigateopd.lna.br:9443
   - If the site is unavailable, access via: https://200.131.64.254:9443
   - NOTE: If the OPD VPN site is unavailable, Remote Observations can also be done via the LNA HQ VPN: LNA HQ VPN Access
2. Observation using the Fortinet VPN application (FortiClient):
   - Download the application from the Fortinet site or the links below:
   - Windows
   - Linux
   - macOS
   - iOS
   - Android
3. FortiClient VPN Setup Instructions for OPD:
   - Fill in the information as shown in Figure 1

Figure 1: VPN Access

- Pre-shared Key: acessovpn1983opd
- `Save` and log in:
  - Username: observerPE01
  - Password: d45RL53L

  If the OPD FortiClient VPN is unavailable, use the following credentials for LNA HQ:
- Pre-shared Key: acessovpn1983sede
- `Save` and log in
- Successful connection:
  - From this point on, a secure connection has been established between your local machine and the LNA internal network. You can now use VNC connections as usual to any authorized IPs.

1.2 VNC Access

- To connect via VNC, a VNC Client must be installed on your computer. Suggestions:
  - Windows: TightVNC, RealVNC
  - Linux: TightVNC, RealVNC, Vinagre
  - macOS: Screen sharing, Chicken
- After connecting via VNC, the local screens will be available:

Machine	IP	Password
TCSPD	200.131.64.236	tks483
S4GUI	200.131.64.170	sparc4acq
Centaurus	200.131.64.170:9	vnc4obs!
Acquisition/Auto Guider	200.131.64.196	tks483

Table 1: VNC Access Passwords for Computers

2 Calibration Procedure

2.1 Initial Setup

1. Unlock the telescope:
   - On TCSPD, go to **UTILS** → **UNLOCK TELESCOPE**
   - In **FIXED POSITIONS**, click **FLAT-FIELD** to move the telescope (Figure 2). This optimizes time so flat images start right after the bias.

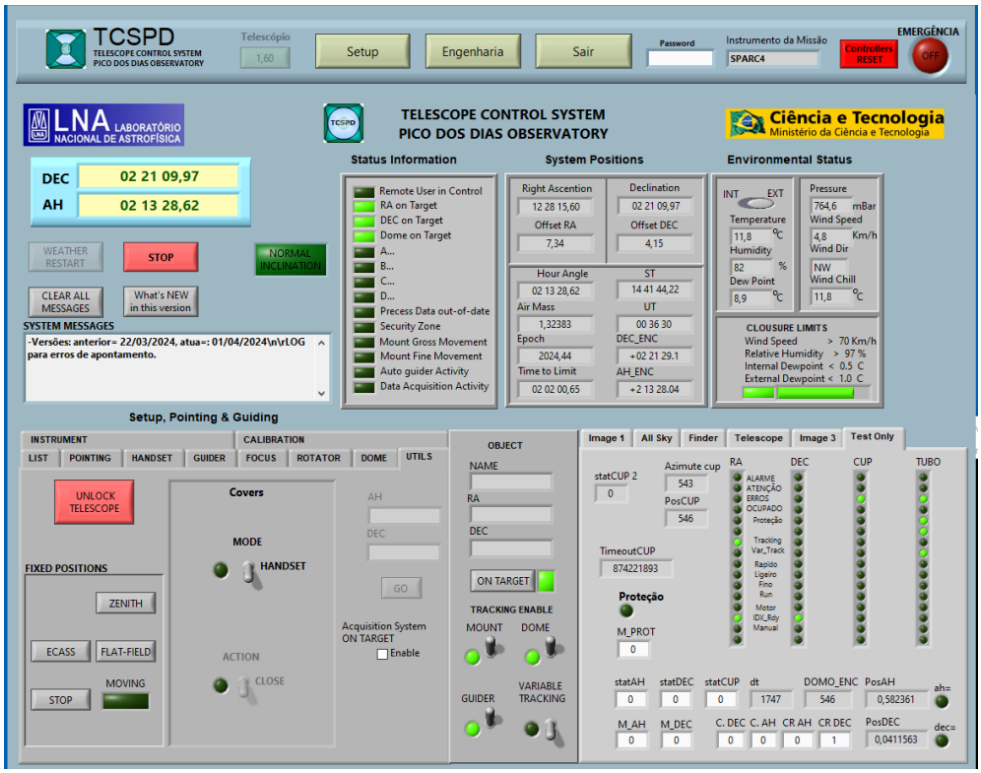

Figure 2: Unlocking the telescope on TCSPD.

2. On the S4GUI screen:
   - Register observers
   - Enter project ID (P-019)

2.2 Bias

1. On the **ZERO** tab of S4GUI:
   - Add the suffix `Bias` to the filename (Figure 3)
   - Set 300 exposures[1]

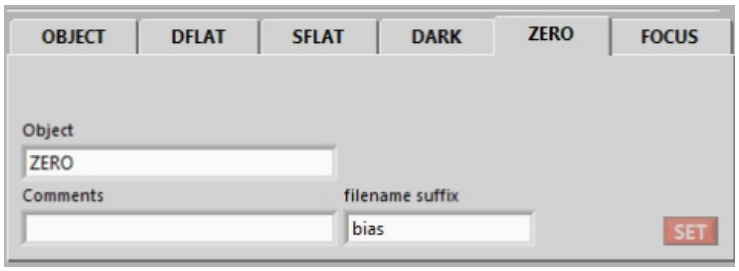

Figure 3: Bias.

2. Verification on Centaurus:
   Always check the images – in the 1st terminal window, type:

   ```
   displatest
   ```

2.3 Flat

1. On TCSPD:
   - Go to **CALIBRATION**
   - Turn on the dim lamp (Figure 4)

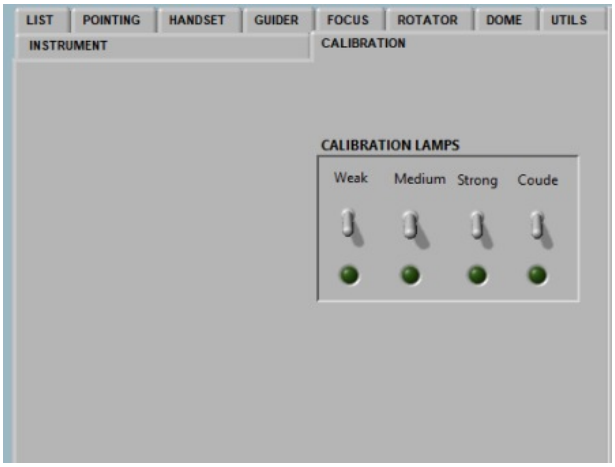

Figure 4: Lamp.

[1]Bias exposure time is standardized at 0.00001s.

2. On S4GUI (**DFLAT** tab):
    - Set a suffix for the filename (Figure 5)
    - Use the tabulated exposure times (50×24, 8×150, 8×150, 10×120)[2]
    - Click **SET** then **START**

Figure 5: Flat.

3. In case of freezing:
    - **RESUME** → **ABORT** → Repeat the process

Just like with bias, flat images can be checked on Centaurus.

3 Observation Procedure

3.1 Field Preparation

1. On the Auto Guider computer:
    - Open Aladin and search for the target galaxy (Figure 6)
    - **File** → **Load instrument FOV** → **Load it** → **sparc4_fov** → **SUBMIT** (Figure 7)
    - Select a nearby field outside the FOV for calibration (Figure 8)
    - Select a centered star in this field

[2]Exposure time and image count per band are fixed based on the mode (conventional), frequency (1 MHz), and gain (gain 2) for this observation type. See Flat Time Table.

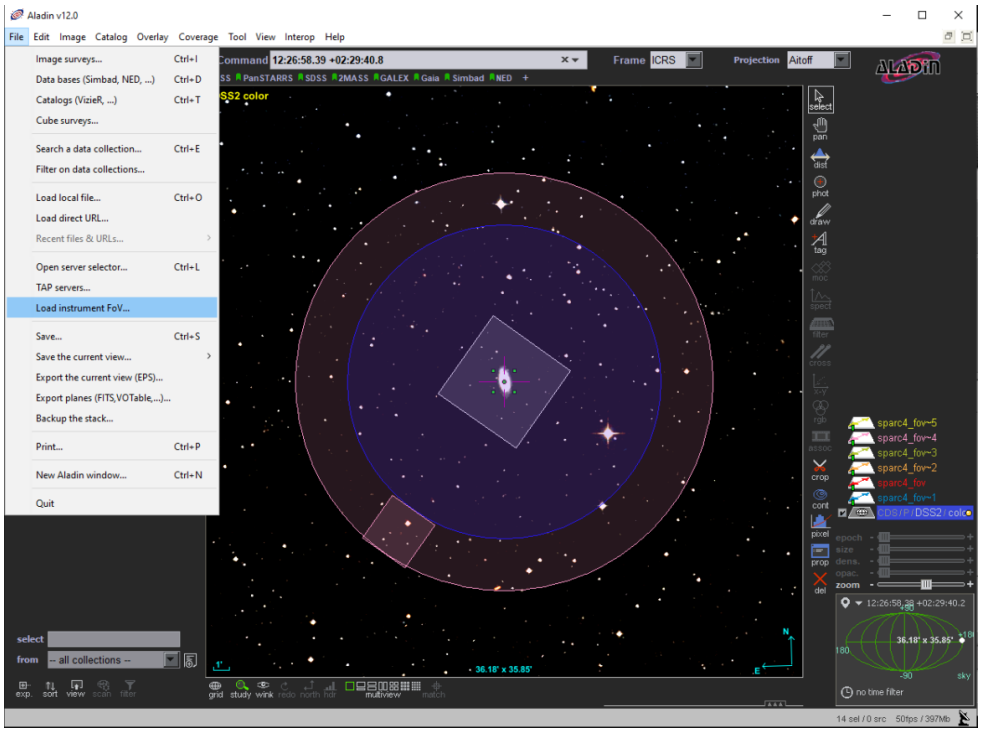

Figure 6: Target galaxy in Aladin.

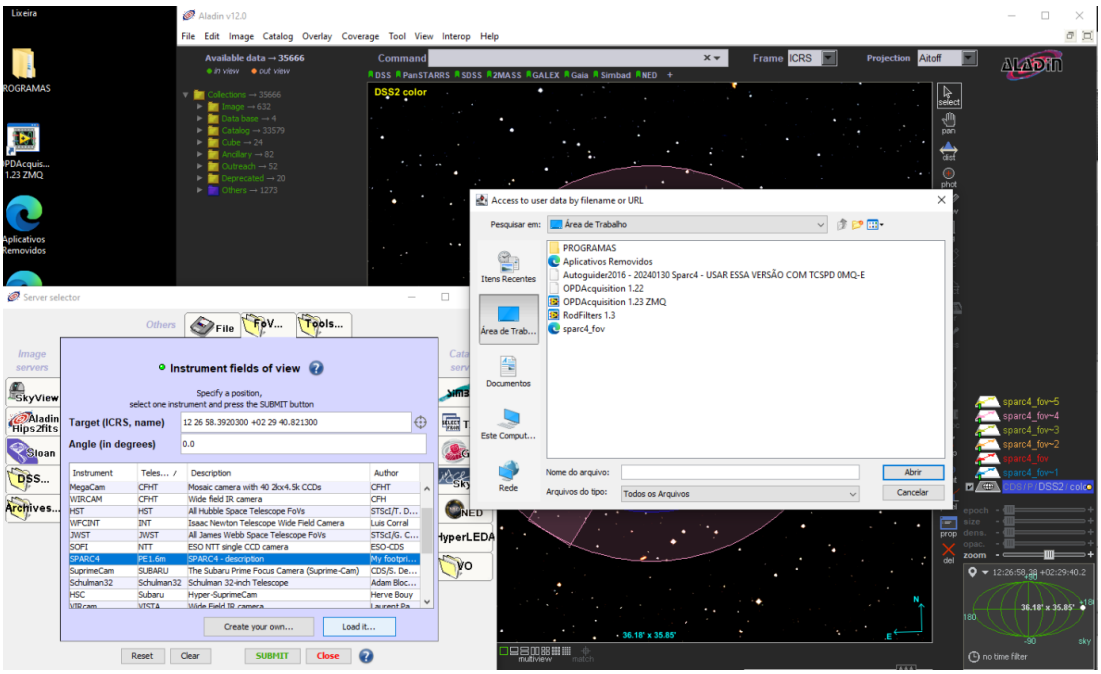

Figure 7: Selecting SPARC4's FOV.

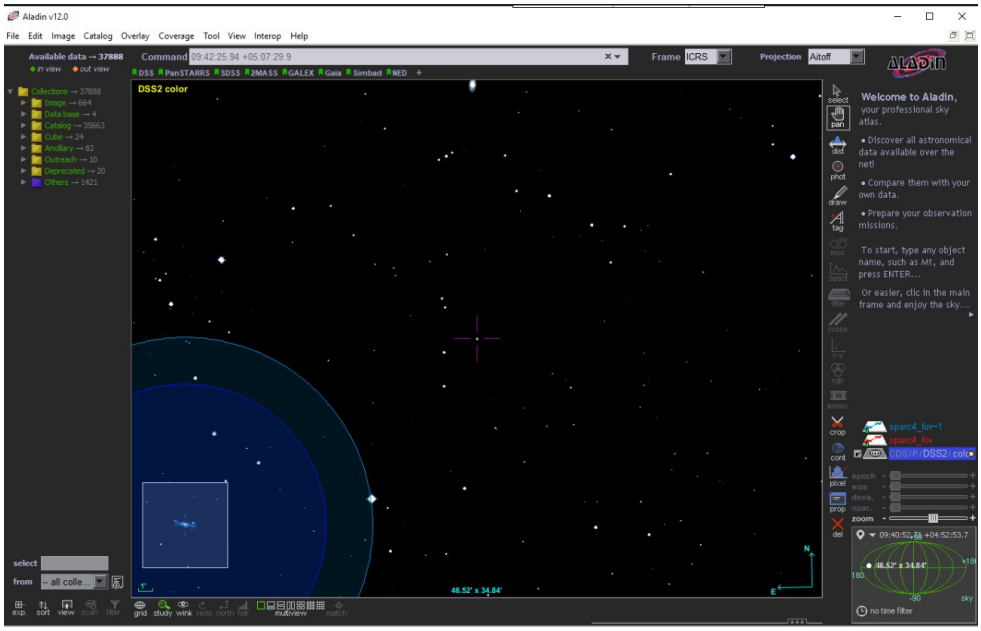

Figure 8: Star field for focus adjustment.

2. On TCSPD:
   - Open the **POINTING** tab
   - Register as *star-field* (suggested)
   - Enter the selected star's RA and DEC coordinates

3.2 Finalizing Flats

1. On TCSPD:
   - Turn off lamp: **CALIBRATION** → deactivate
   - Open dome: **DOME** → **OPEN** (Figure 9)

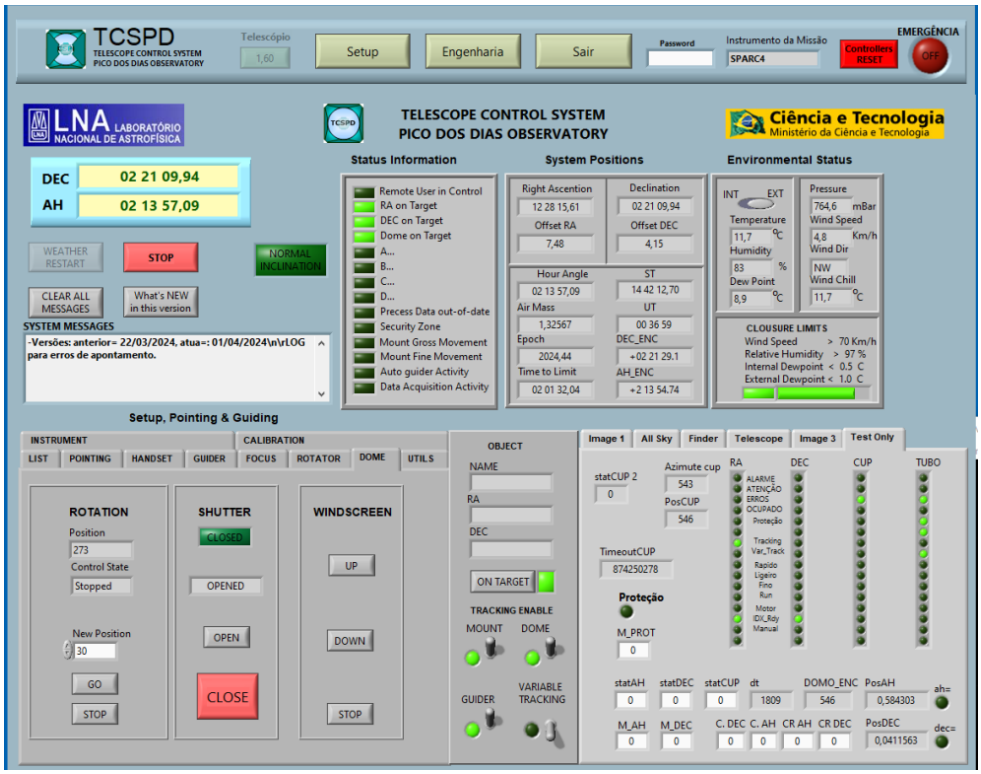

Figure 9: Dome control interface.

2. Return to the **POINTING** tab:
   - Click **PRECESS**
   - Click **POINT**
   - Confirm message *WORKING AREA IN* (telescope ready)

3.3 Focus Adjustment

1. On S4GUI (**FOCUS** tab):
   - Name the object: *star-field*
   - Set suffix for images (suggested: *focus1*, Figure 10)
   - Set: 1 exposure of 5s for all bands
   - **SET** → **START**

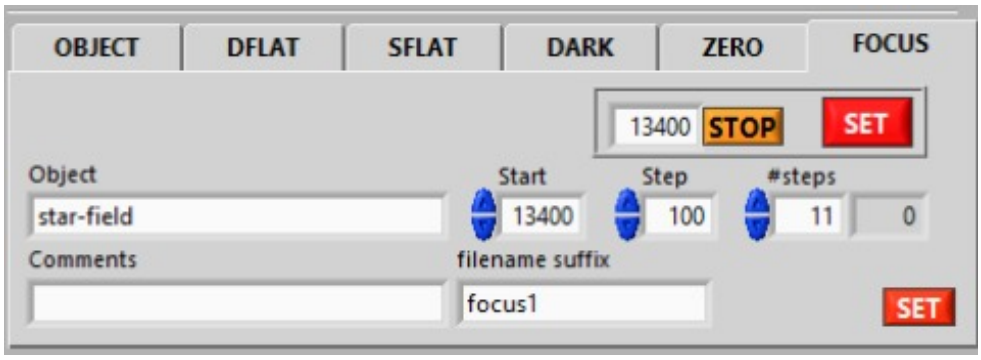

Figure 10: Pointing to star field for focus adjustment.

A field with several stars is best for proper pipeline operation. A bad focus leads to a larger FWHM and worse seeing. The best focus value used in the last observation (July 2025) was 14010.

2. On Centaurus (2nd terminal window):

   - Run the command[3]:

     ```
     python -W"ignore" /home/observer/sparc4-pipeline/tools/sparc4_focus.py
     --nightdir=today --seq_suffix=focus -v
     ```

   - The pipeline will return a *best mean FOCUS* value. Enter it into TCSPD (**FOCUS** tab → *target*)
   - Click **GO**
   - Check *Focus Status* for confirmation (Figure 11)

[3]This command is likely already saved in the terminal history; just press up arrow and Enter.

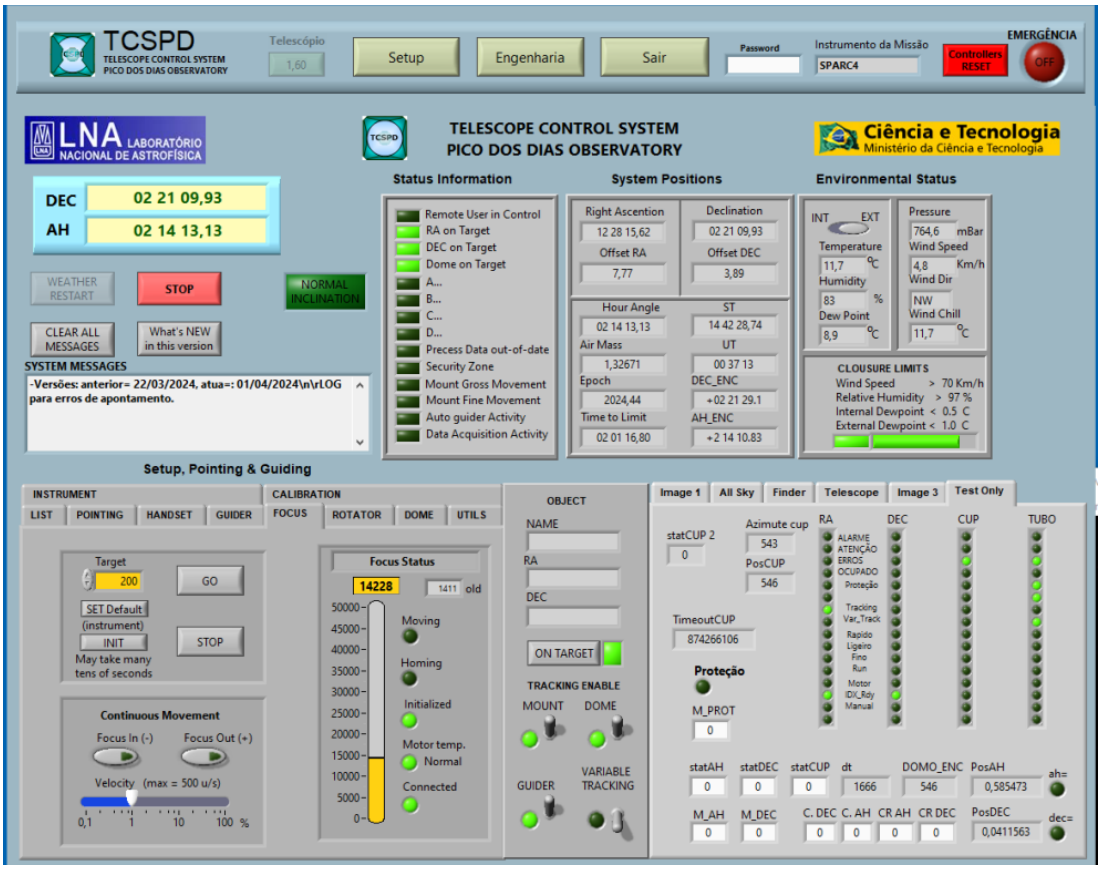

Figure 11: Focus adjustment interface.

4 Science Target Configuration

1. On the **POINTING** tab of TCSPD:
   - Register target name (Figure 12)
   - Enter coordinates (RA/DEC)
   - Click **PRECESS** then **POINT**

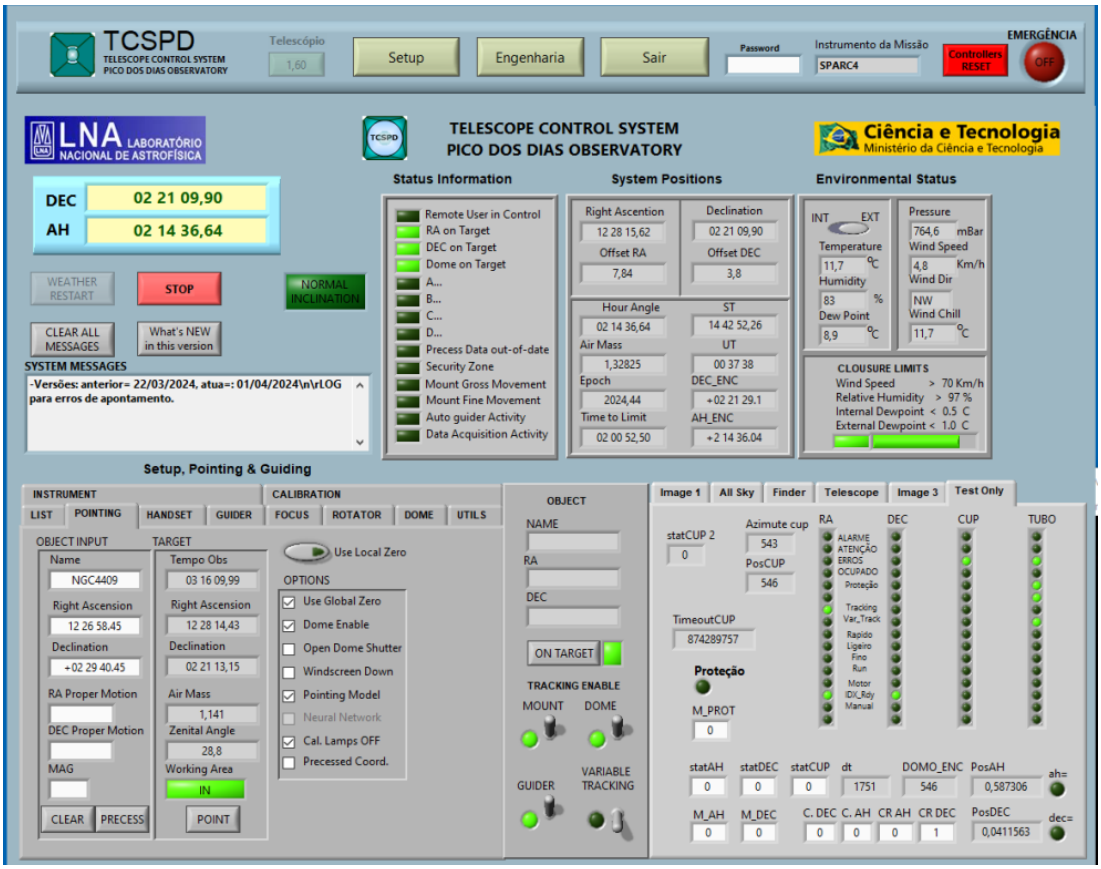

Figure 12: Pointing configuration.

2. On the S4GUI screen (**OBJECT** tab):
   - Register object name (e.g., NGC2966, Figure 13)
   - Add suffix (e.g., ngc2966)
   - Prepare a test exposure (5–10s) to evaluate saturation (see section 4.2)

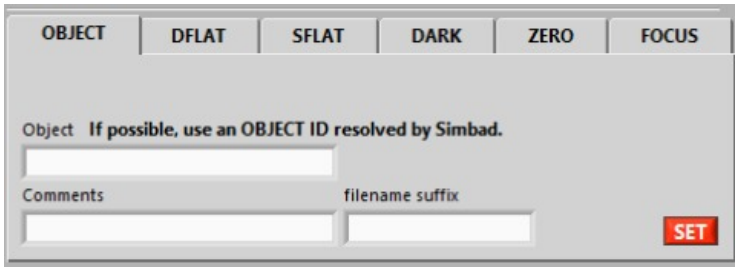

Figure 13: Science object.

4.1 Autoguider Setup

1. In Aladin, for the 1st science target:
   - Select a bright star inside the SPARC4 FOV (pink area, Figure 14)
   - Note the blue number (*Rotation Angle*)
2. For all targets after the 1st:
   - Open Aladin and search for the target galaxy (Figure 6)
   - **File → Load instrument FOV → Load it → sparc4_fov → SUBMIT** (Figure 7)
   - Select a bright star in the SPARC4 FOV (pink area, Figure 14)
   - Note the *Rotation Angle* in blue

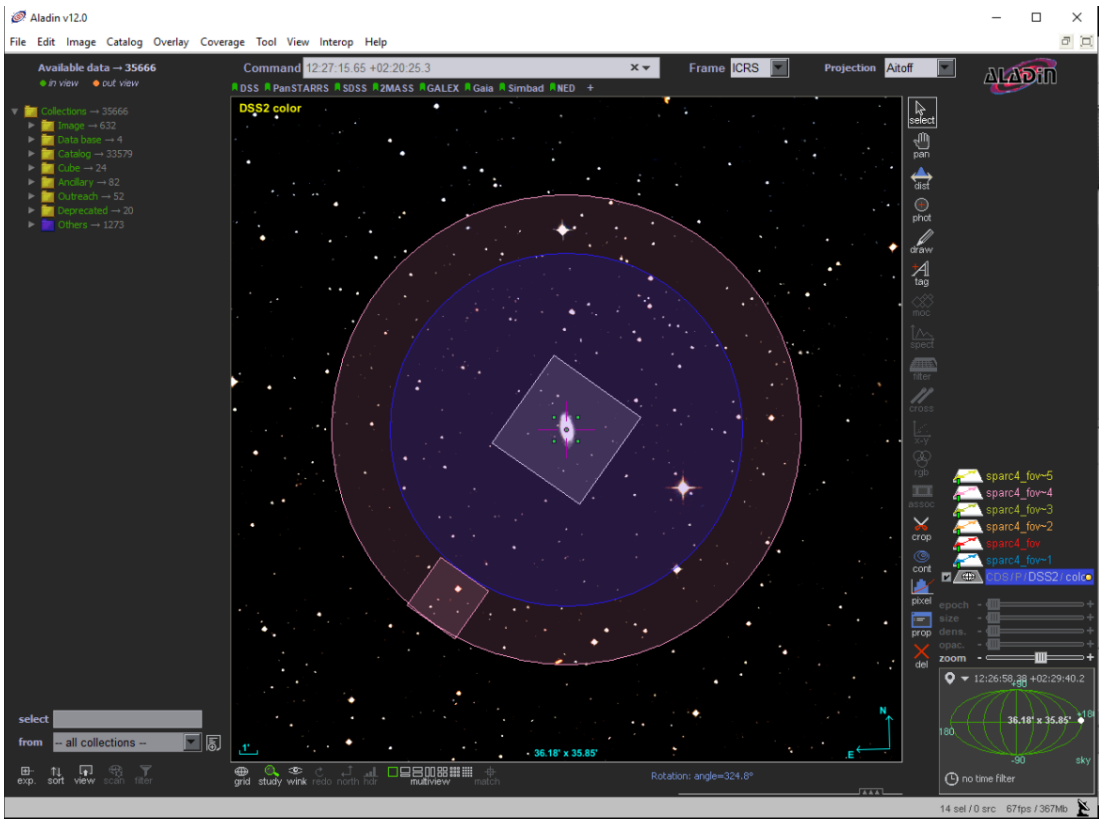

Figure 14: Selecting guide star in Aladin.

3. On the S4GUI computer:
   - Open **Guider Setup** (Figure 15)
   - Enter angle in *target*
   - Click **GO TO**
   - Check focus value (reference: 17 for photometric mode)

- Click **GO TO** again

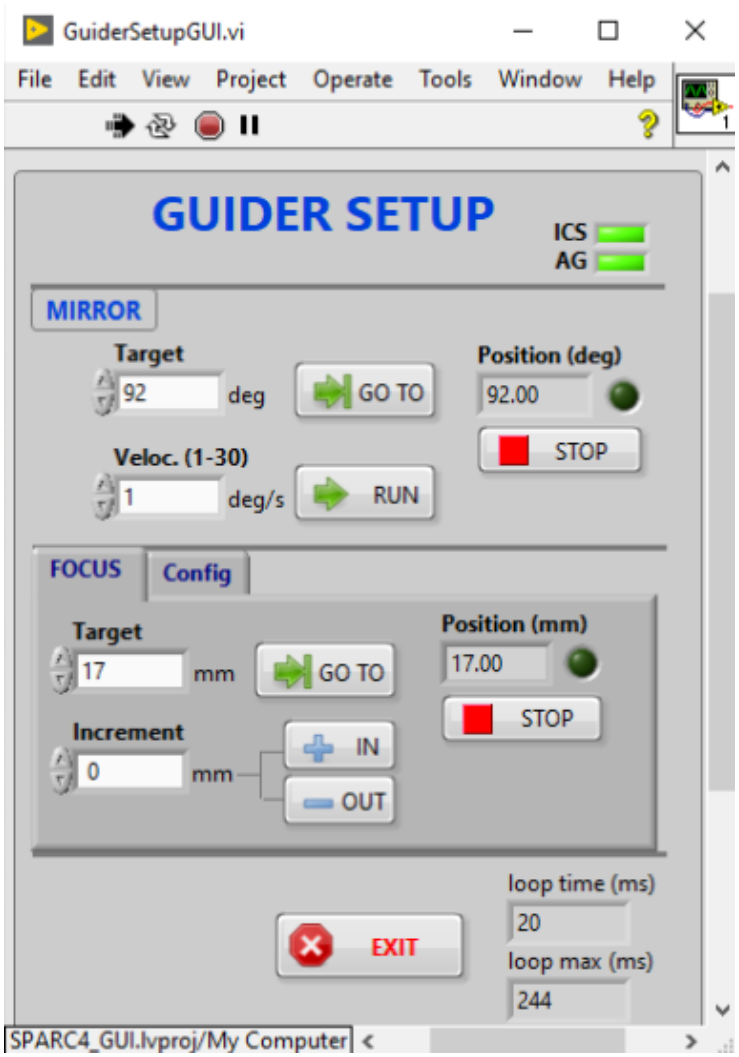

Figure 15: Guider setup.

4. On the Autoguider screen:
   - Activate *video*
   - Adjust color scale for better visibility
   - Center the crosshairs on the star
   - Activate *Guide* (Figure 16)

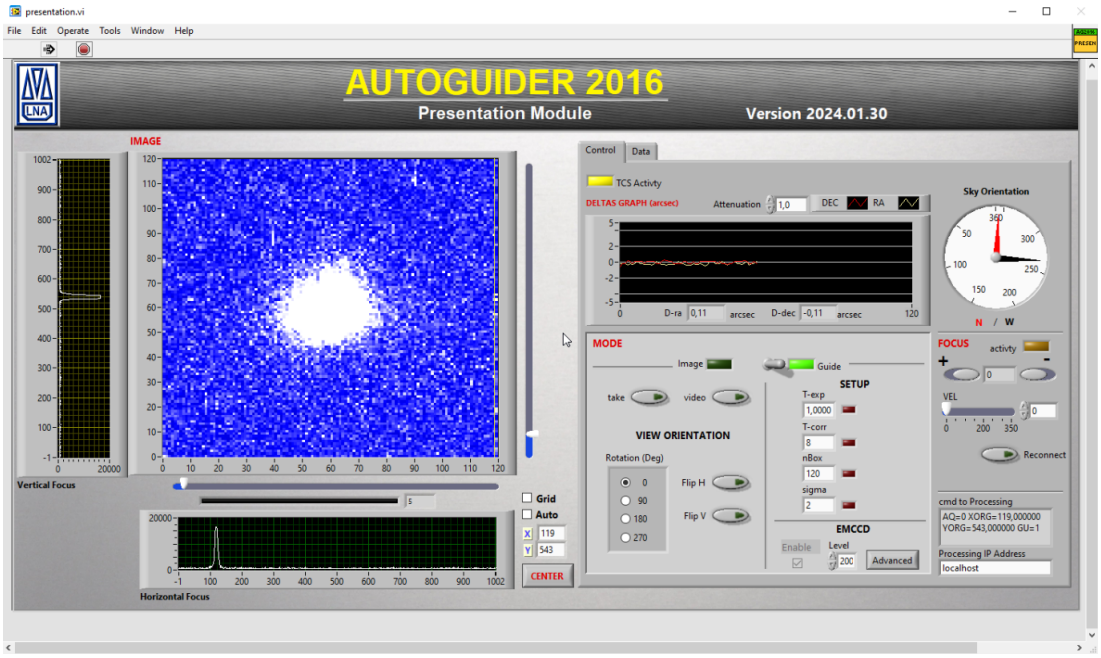

Figure 16: Autoguider interface.

5. In case of issues:
   - Deactivate *Guide* and *video*
   - Enable EMCCD
   - Increase *level* (e.g., 120)
   - Check the graph

4.2 Exposure Time Calculation

- Procedure:
  1. Perform a test exposure on S4GUI (**SET** → **START**)
  2. On Centaurus:
     - Run `displateste` on the 1st terminal
     - Use `imexam` to analyze each band (g, r, i, z)
     - Select a nearby star and press `r` to plot its radial profile

Exposure time rule:

$$t_{galaxy} = \frac{\sim 36000 \times t_\star}{cont_\star}$$

- $t_\star$: test exposure time (5–10s)
- $cont_\star$: maximum star count
- 36000: 60% of the saturation limit (60000 ADU) for this gain (=2)

t_{galaxy} is the estimated exposure time to observe the galaxy in each band. Each of these values should be rounded to the nearest multiple of 600. This is because the total exposure time per target should be 5400 seconds (1h30min), distributed over 9 dithering positions (starting from position 3 in Figure 17, moving up and down until returning to the initial position)[4].

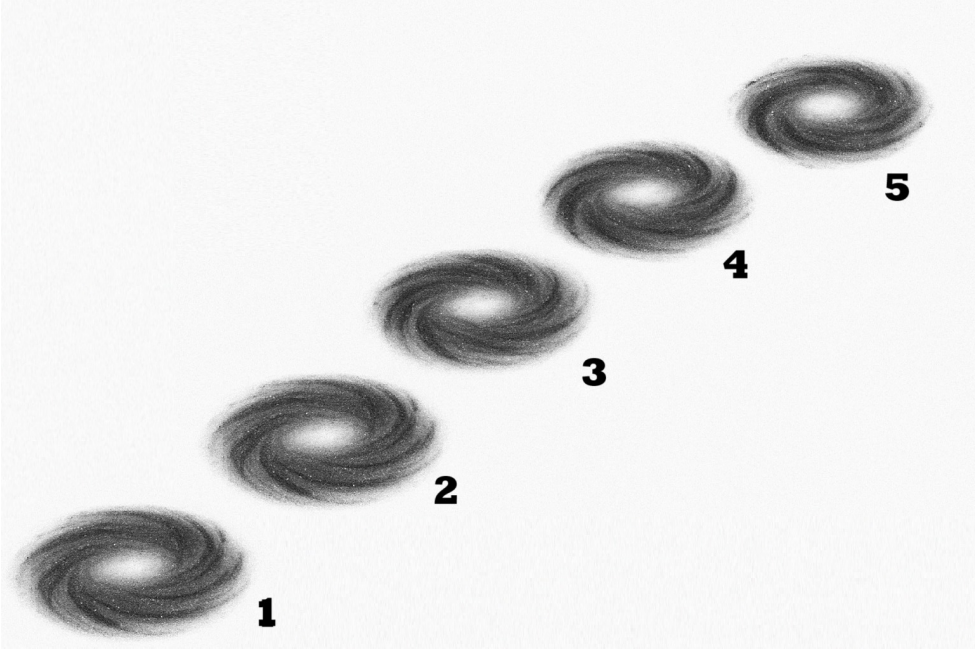

Figure 17: Dithering sequence.

Each dithering position requires 600 seconds of total exposure, divided across the 4 bands (g, r, i, z) based on the saturation level calculated for each.

1. On the **S4GUI** screen:
    - Fill in the fields for each band (Figure 18):
        - *Exptime*: insert the calculated time
        - *Exp*: set the number of exposures
    - Click **SET** then **START**

[4]Dithering consists of slightly shifting the telescope's pointing between exposures. This helps remove artifacts such as hot pixels or bad columns during post-processing.

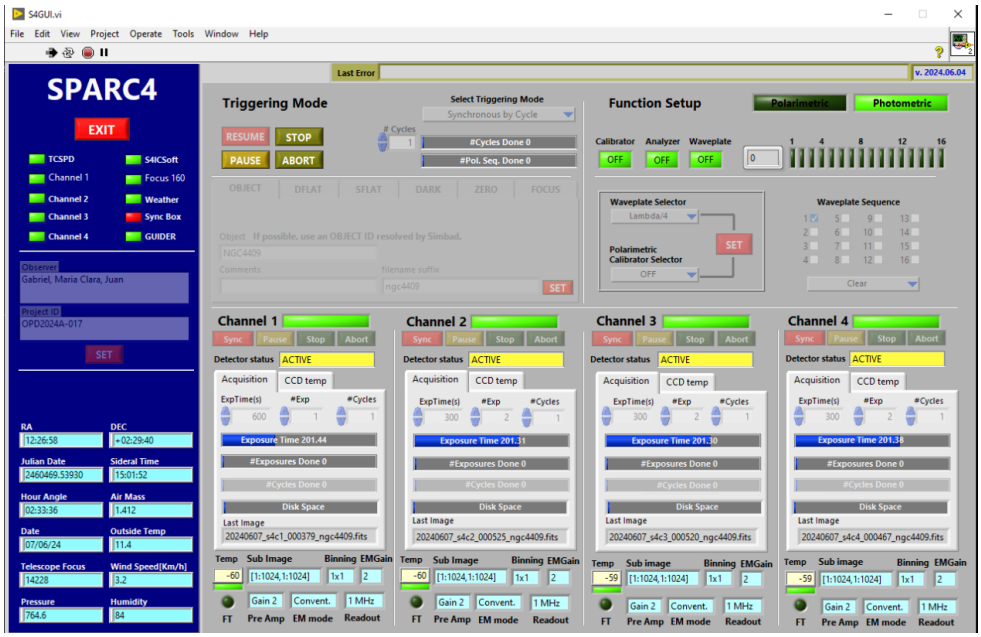

Figure 18: S4GUI interface.

4.3 Dithering Configuration

1. Procedure:
    - Deactivate *Guide* in the Autoguider
    - On TCSPD (**HANDSET** tab):
        - Set *Precise offset* in 3.00 arcsec steps in RA and DEC (Figure 19)
        - Click **GO**
    - Reactivate guiding

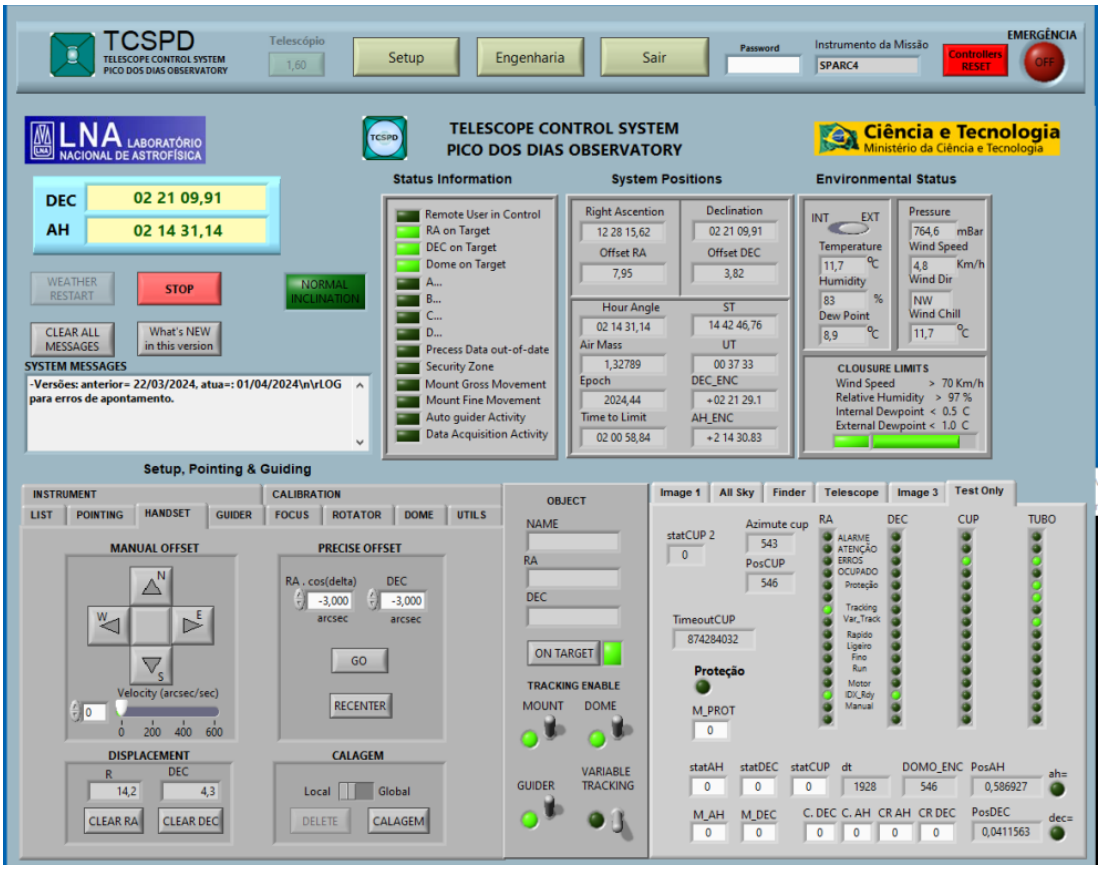

Figure 19: Dithering configuration.

For each dithering step, check the counts in the 4-band images. Repeat the procedure in subsection 4.3 until returning to the initial pointing position. For a new science target, repeat the steps starting from Section 4.

4.4 Seeing Estimation

To estimate the seeing in a specific band, follow the same procedure used to check counts in the previous section (`imexam` → press `r`).

1. IRAF provides three FWHM values in the generated graph:
   - Simple FWHM
   - **Gaussian FWHM (middle value)** – used for our calculations
   - Half Flux Radius
2. Seeing calculation:
   - Instrument pixel scale (SPARC4: 0.337 arcsec/pixel)
   - Multiply FWHM in pixels by pixel scale:

$$\text{Seeing (arcsec)} = \text{FWHM (pixels)} \times 0.337$$

- Gaussian FWHM is chosen because it better fits the theoretical stellar profile
- **Seeing depends on the observed band**, typically being better (smaller) in longer wavelengths (e.g., infrared) than in shorter ones (e.g., ultraviolet)
- For higher accuracy, it is recommended to **measure several stars** in the field and calculate the average of the FWHMs obtained

Useful IRAF Commands

- `displatest`: Displays the latest images
- `imexam`: Detailed pixel analysis
  - `r`: Radial profile plot
  - `l`: Line analysis
  - `c`: Column analysis