

EAGLE CORE

control unit for astrophotography with DSLR and mirrorless camera

VERSION 2.10

Update 03-03-2021



PLUS



EAGLE CORE is manufactured by PrimaLuceLab S.p.A. (Italy). For any matters relating to the use, service and warranty, please refer to the addresses given in the relevant documents.

English

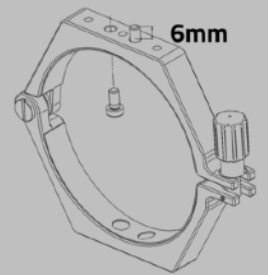
Thanks for purchasing EAGLE CORE, the wireless control unit that makes fast and easy astrophotography with DSLR or mirrorless cameras. In the first part of this manual you will find all the explanations on how to use EAGLE CORE. In the second part you will find a guide on how to start astrophotography using EAGLE CORE with telescopes and photo lenses.

CAUTION: To avoid danger of electric shock and malfunction, do not expose EAGLE CORE to rain or moisture. The electronics are not waterproof so in adverse weather like rain or snow, the EAGLE CORE is not to be used outdoors.

FIRST CONNECTION: For wireless connectivity, EAGLE CORE creates a WiFi network at the same frequency as those of usually modems / routers used to connect to the internet. So if you use EAGLE CORE at home (for example the first time, to install your software) you might notice a low signal or, in some cases, have connection problems.

QUALITY CONTROL: After assembly in our laboratories, every EAGLE CORE unit, is tested by PrimaLuceLab technical experts to verify the correct operation of all components = the integrated computer, stability and speed of the wireless connection and the power bridge.

CAUTION: in order to connect EAGLE CORE to other mechanical PLUS elements please avoid to use too long screws that may touch the internal electronics of the EAGLE CORE. **THE THREADED PART OF THE SCREW THAT EXIT FROM THE ELEMENT (ring, bar or clamp) TO BE CONNECTED TO THE EAGLE HAS TO BE NO LONGER THAN 6mm.** If any of the screws touches the internal elements of EAGLE CORE, this could lead to breakage or malfunction.



CAUTION: EAGLE CORE is 12V powered but it can be powered with a voltage from 9V to 16V. Caution: the voltage of the output power ports depends strictly on the input voltage. If any of the devices powered by EAGLE CORE is supplied with a voltage other than the one provided, there may be malfunctions or damage. We recommend to power EAGLE CORE via an external 12V power supply or a battery. If you use an external battery, this **MUST** be equipped with a special voltage stabilizer. Immediately disconnect power supplies or power supply if you have any malfunction of the unit.

CAUTION: EAGLE must be powered with 12V regulated voltage. You can use a power supply with 12V output voltage or a field battery. If you use a battery, this **MUST** be provided with a proper voltage stabilization. In case of any malfunction, immediately unplug the power supply. **DO NOT CONNECT TO THE EAGLE CORE A BATTERY WITHOUT 12V VOLTAGE REGULATOR** since it may damage the other instruments powered by EAGLE CORE. Immediately disconnect power supplies or battery if there's any malfunction of the unit.

For any questions regarding use, service, and warranty, please refer to the addresses provided in the relevant documents. Canon, Nikon, SolidEdge, Simulation Curriculum, SkyWatcher, and Celestron trademarks belong to the legitimate owners and have been used for the sole purpose of explaining and for the benefit of the user in this manual without any violation of the applicable Copyright laws.

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Quick guide

For EAGLE CORE operation, it is essential to correctly set the DSLR or mirrorless camera, the equatorial mount and the autoguide camera. This table summarizes what needs to be set, please read the following paragraphs of this manual before using EAGLE CORE with your telescope.

DEVICE:	HOW TO SET:
DSLR or mirrorless camera:	<ul style="list-style-type: none"> - M (or B if present) mode. - Manual focus if you use a telephoto lens instead of a telescope. - used with a free memory card (we suggest to format the memory card before use with EAGLE CORE). - set without auto noise removal (auto dark). - set without mirror lock up. - set without automatic rotation of the image
Equatorial mount:	<ul style="list-style-type: none"> - Corrected aligned to the Pole. - Aligned to the stars and with automatic tracking active. - Correct weight balance.
Autoguide system:	<ul style="list-style-type: none"> - Autoguide camera connected to ST4 port of the mount.
Power system:	<ul style="list-style-type: none"> - Battery 12V fully charged and with sufficient capacity to power the entire telescope for many hours or power supply.

Scope of delivery and parts identifications

- 1) EAGLE CORE control unit
- 2) 12V power cable with cigarette plug for Eagle (length 110cm)
- 3) 4 M6x12 screws, 4 M6x8 screws
- 4) Quick guide

The numbers indicate the name of the component listed below. Read the following paragraphs for details on operation.

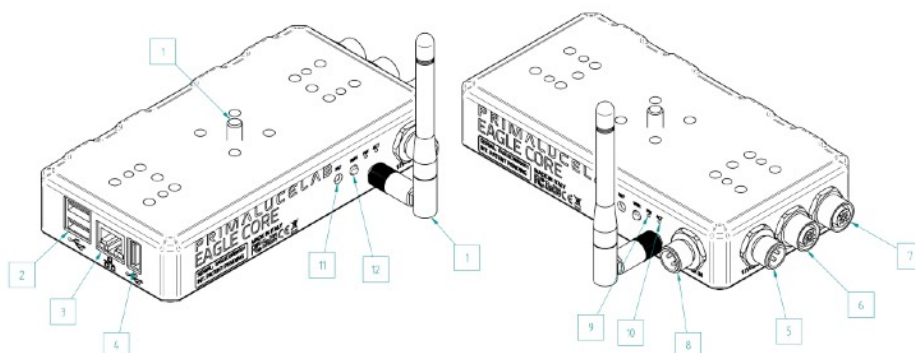


Image 1

- 1) Wi-Fi antenna
- 2) N°2 USB 2.0 ports
- 3) Ethernet port
- 4) N°1 USB 2.0 port
- 5) 12V 3A power out port
- 6) 12V 3A power out port
- 7) 12V 5A power out port
- 8) 12V power in port
- 9) "PW" LED signal
- 10) "ACT" LED signal
- 11) "RST" reset button
- 12) "WIFI" button

First use: power on and wireless network activation

EAGLE CORE control unit is designed to be controlled by an external device (not included in the package). You can use any mobile device (tablet or smartphone) with any operating system (iOS or Android) or another computer (Windows or macOS). Take the WiFi antenna included in the EAGLE CORE box and screw it into the appropriate port (Image 2).

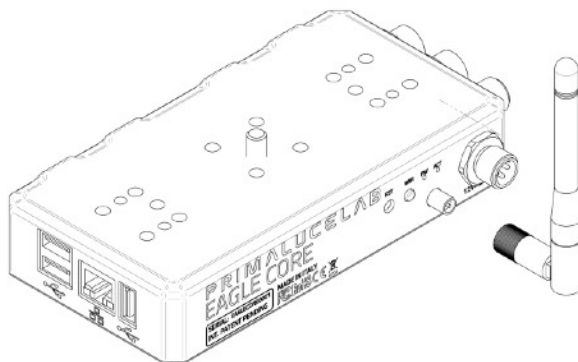


Image 2

Please insert in the appropriate power plug (8 - 12V power IN port) the 12V power cable with cigarette plug included in the package (image 3). This way you can power the EAGLE CORE using 12V field battery with cigarette plug. If you want to power it with a wall plug, you can use the optional “AC adapter for Eagle”.

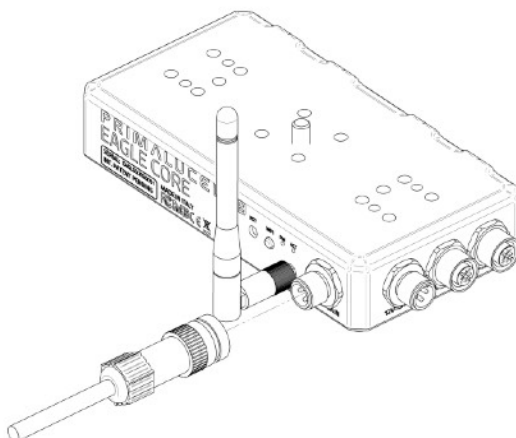
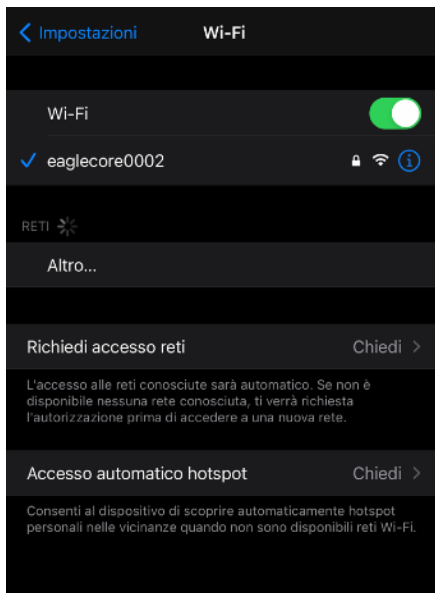


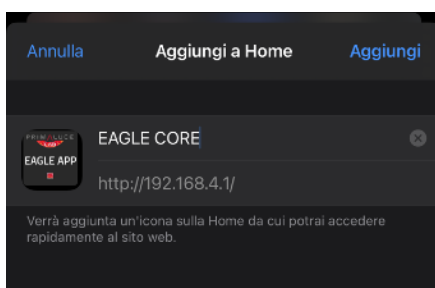
Image 3

Once powered, the “PW” and “ACT” LED lights will turn on. After more or less 40 seconds EAGLE CORE emits a sound, this means the WiFi connection is active and you can use your WiFi device to control EAGLE CORE. Once powered, EAGLE CORE starts EAGLE OS and creates a Wi-Fi network that can be accessed with a smartphone, tablet, or computer. For security reason, each EAGLE CORE device creates a different WiFi network than the other EAGLE CORE units, and the access password is the same for each device (but you can modify it).

How to connect to EAGLE CORE using an iOS device (iPhone or iPad)

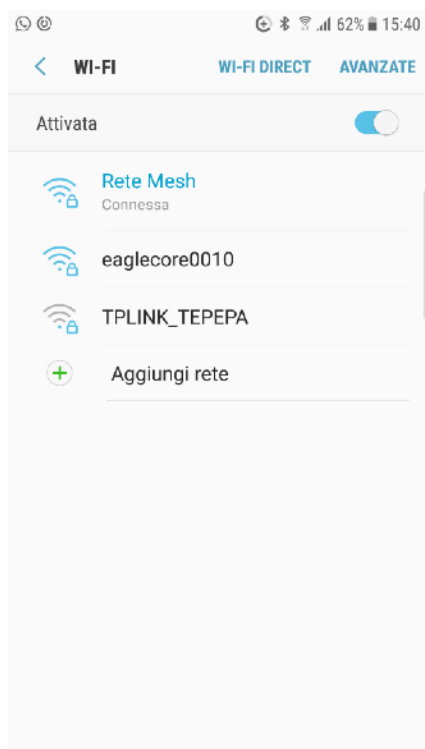


If you are using any iOS device like iPhone or iPad, first of all you need to access the device settings, activate Wi-Fi, and select the eaglecorexxxx network (the name of the network depends on the serial number of EAGLE CORE and it's printed on the white label in the EAGLE CORE case, in this case eaglecore002). Using the keyboard (virtual or physical) of your device insert "eaglecore" as the default password and then press the "Login" button. The next time you want to access EAGLE CORE, you will no longer have to enter your password: your device will automatically connect when you select the network created by EAGLE CORE unless you change the login password.

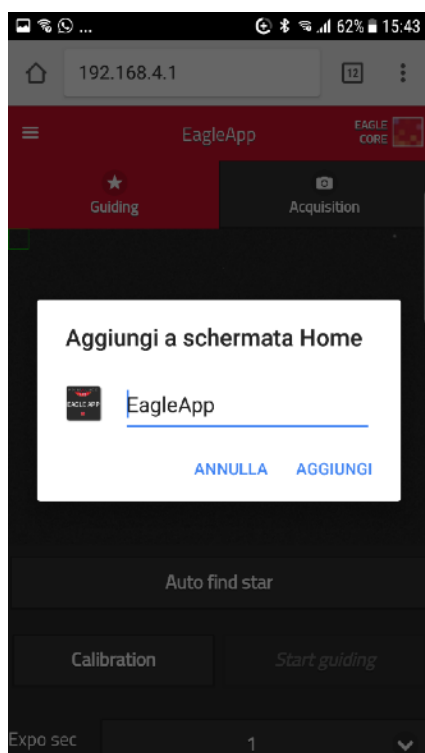


Now you can open the browser of the iOS device (for example Safari), in the url area (in the field where you usually write the url like www.primalucelab.com) and type the address 192.168.4.1 and press the button RETURN to access the EAGLE CORE. To create a link directly to your iOS device desktop, simply press the "share" button and then "Add to Home". Now we can give a name, "EAGLE CORE" and have a direct and immediate connection to EAGLE CORE.

How to connect to EAGLE CORE using an Android device



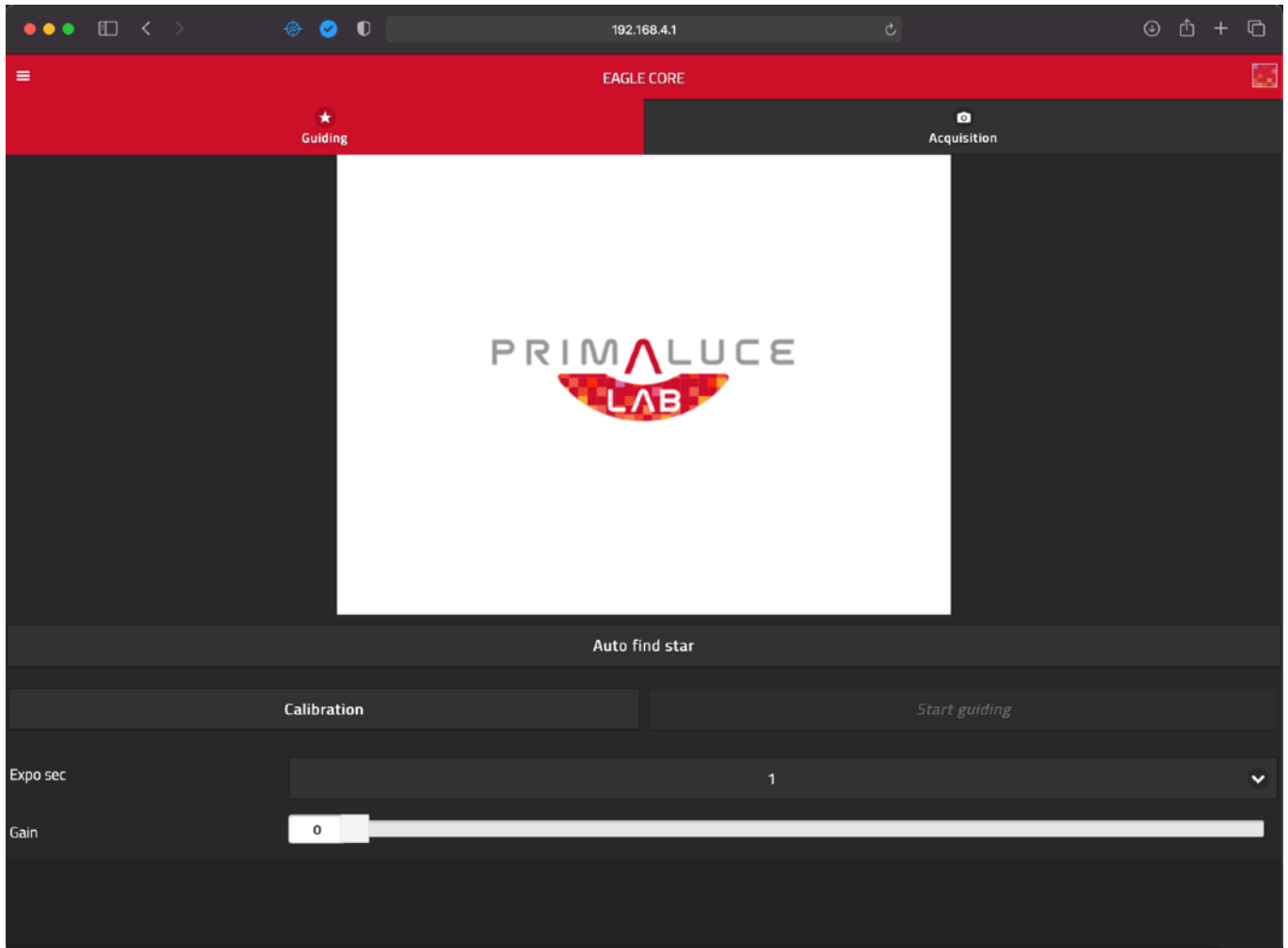
If you use an Android device, you need to access the settings, activate Wi-Fi and select the eaglecorexxxx network (the name of the network depends on the serial number of EAGLE CORE and is printed on the white label EAGLE CORE case, in this case Eaglecore005). Using the keyboard (virtual or physical) of your device insert "eaglecore" as the default password and then press the "Login" key. The next time you want to access EAGLE CORE, you will no longer have to enter your password: your device will automatically connect when you select the network created by EAGLE CORE, unless you change the login password.



Now open the Android device browser (for example Chrome), type the address 192.168.4.1 (in the field where you usually enter the address of an internet website like www.primalucelab.com) and press ENTER button to access EAGLE CORE. To create a link directly on your desktop just press the dashed button on the top right and then "Add to Home". Now we can give a name, "EAGLE CORE App" and have a direct and immediate link to EAGLE CORE.

How to connect to EAGLE CORE with a PC or Mac

You can connect to EAGLE CORE and then use EAGLE CORE App also from a Windows or Mac computer. You need to access the settings of your computer, activate Wi-Fi and select the eaglecorexxxx network. When prompted, enter "eaglecore" as the default password, and then press the "Sign In". Now open your computer browser, enter address 192.168.4.1 and press keyboard ENTER button to access EAGLE CORE.



You can also access EAGLE CORE also via a network cable. Connect a network cable from your computer (PC or Mac) to EAGLE CORE and open your computer browser. Now type 192.168.0.250 address, press keyboard ENTER button and access the EAGLE CORE features.

Before using EAGLE CORE: set your camera

Before using EAGLE CORE you have to:

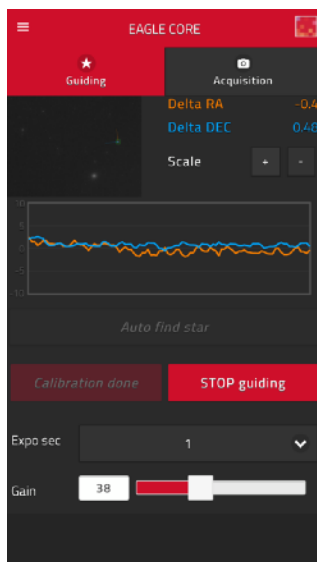
- Set your camera to manual mode "M" or, if present, in "B" mode (based on your camera model).
- In the camera, deselect auto noise reduction (auto dark) and mirror lock up.
- Using the USB cable of the camera, connect it to one of the EAGLE CORE USB ports.
- Check the battery of your camera is charged (we recommend using "Eagle-compatible power cable for Canon EOS and Nikon DSLR camera").
- Insert a memory card with sufficient free space. At first use, we recommend formatting the memory card using the camera menu.
- If you want to shoot with a photo lens, set it in manual focus mode

EAGLE CORE App: EAGLE CORE control interface

The EAGLE CORE control interface, **EAGLE CORE app**, has been created for use in *touch* mode (as you typically do with your tablet or smartphone): with a simple "tap" on an EAGLE CORE App icon, EAGLE CORE performs a function or it has a different menu. The interface has been designed to make it easier to capture images of celestial objects, avoiding unnecessary and difficult settings and providing in a few steps the information needed to record astrophotures. You do not even have to add software, all you need to do astrophotography with DSLR compatible cameras is already present in EAGLE CORE.

EAGLE CORE App is divided into two main tabs: **Guiding** and **Acquisition**. In the Guiding tab, you can manage all the functions of the guide camera, while in the Acquisition tab, you can find camera and image capture controls. The "Menu" button at the top left allows you to access the EAGLE CORE settings and advanced settings.

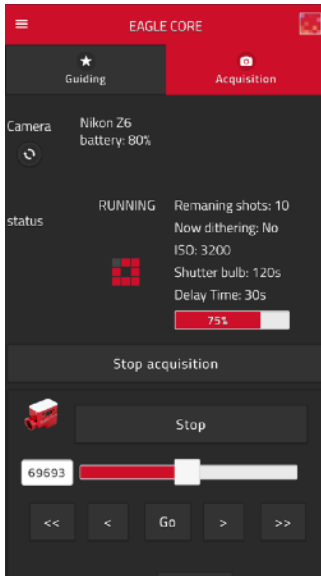
"Guiding" tab



As seen above, in the "Guiding" tab you have access to all the features needed for autoguide (autoguide introduction on page 95). At the center of the screen you see the real-time image taken from the used guide camera. Here you can set the exposition time, gain, calibrate and start the autoguide.

For more information on how to autoguide with EAGLE CORE, read "Start the autoguide" paragraph.

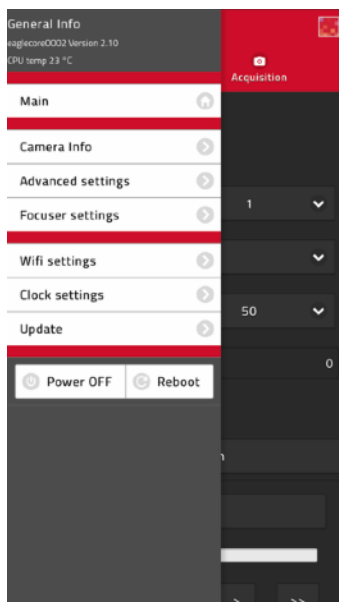
“Acquisition” tab



In the "Acquisition" tab you can set the capture parameters and manages all the operations of the camera used (focus and capture images).

For more information on how to capture images with EAGLE CORE, see "Capture images with DSLR camera" paragraph.

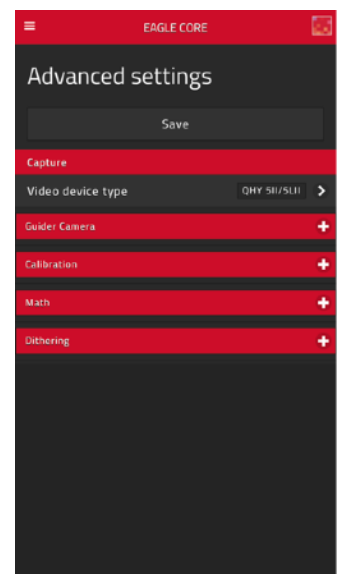
EAGLE CORE advanced settings



With a Tap on the Menu button you will sequentially see a series of functions. First of all the general system information such as the version of EAGLE OS, and the CPU temperature. Clicking on "Main" button you will return to the "Guiding" screen and the control parameters. The "Camera Settings" button allows you to have a first access to the connected camera. EAGLE CORE automatically recognizes the connected DSLR camera and reports the status of the battery. To avoid running out of battery, we recommend using the “Eagle-compatible power cable for Canon EOS and Nikon DSLR camera“, available for many reflex models often used in astro photography. With a "Tap" on "Advanced settings", you access the guide camera selection; by default in EAGLE CORE the simulator is set as default, in this window you can select the guide camera used (eg QHY5L-II).

Then, in the Guider Camera field you can set the diameter (Aperture) and focal length (Focal) in millimeters of the guide scope. The values of the "60mm CompactGuide Guide Telescope" (optional) are preset, but you can modify them at will. Below you

can see the parameters (resolution and pixel size) of the guide camera. Parameters are automatically detected by EAGLE CORE. After selecting the guide camera and checking the parameters of the guide scope, click "Save" to confirm (if you do not click Save, EAGLE CORE will keep the Simulator as guide camera).





SESTO SENSO settings

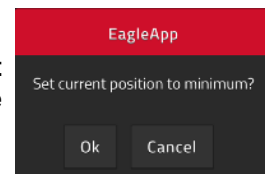
ATTENTION: it is necessary that both *SESTO SENSO* and *EAGLE CORE* firmwares are updated to version 2.0 or later. Before continuing with the *SESTO SENSO* calibration it is necessary to install it on your telescope following the instructions in the *SESTO SENSO* manual.

Starting version 2.0 of EAGLE CORE App, you can manage the setting for SESTO SENSO (1st or 2nd generation) robotic focusing motor using EAGLE CORE. Selecting SestoSensio settings, you access the SESTO SENSO management menu. If SESTO SENSO has not yet been calibrated, the window will appear as shown in the figure, stating the firmware version, the temperature detected (if connected to the optional temperature sensor) and the current position.

Calibration procedure:

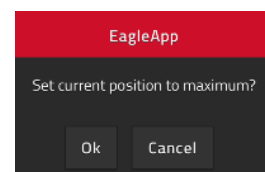
Manually bring (by turning the focuser knob) the focuser to about halfway of the focuser travel, then using the "Slow +" or "Slow -" and "Fast +" or "Fast -" buttons bring your focuser to the most position internal and then press the "Stop" button when you have reached it (you do not have to go to the stop point of your focuser but you can stop 1 or 2 mm before the end of movement). Do not worry if the buttons work in the opposite direction, they are only used for calibration.

Warning: take care to stop the engine (by pressing the Stop button) BEFORE it reaches the end of the focuser, otherwise the focuser or the SESTO SENSO engine may break.

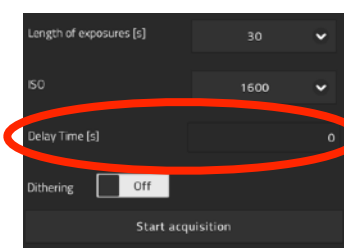


Then press the button "Set position to 0", a new window is opened in which confirmation is requested "Set current position to minimum?". By confirming with OK we have set the minimum point of focuser travel. Now in the opposite direction, with the "Slow -" and "Slow +" or "Fast -" and "Fast +" buttons, move your focuser to the outermost position. As before, stop 1 or 2 mm before the end of travel (remembering to avoid letting go of the engine at the end of the travel as it may brake your focuser or SESTO SENSO motor) by pressing the STOP button. Press the "Set position to MAX" button, as before appears a new window that asks you to confirm that the current position is the maximum position "Set current position to maximum?". Press OK and SESTO SENSO calibration will be done.

WARNING: never disconnect the USB or power cable between the EAGLE CORE and SESTO SENSO while the "ACT" LED is on, ALWAYS turn off EAGLE CORE by using the off button and wait until the "ACT" LED is off before removing the power to EAGLE CORE. If one of the above conditions occurs, the calibration procedure must be repeated to avoid breaking the SESTO SENSO focuser or motor.



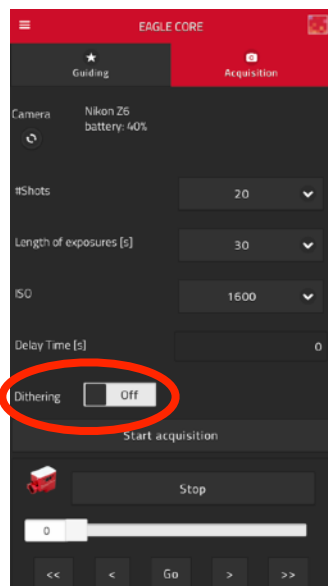
NOTA: if, after calibration, you move the focuser by hand (this way losing the calibration), manually move the focuser in innermost position and press the "Set position to 0" button.



Delay Time [s]

Here you can set a "Delay" time that is a "waiting" time between consecutive pictures. This setting is useful to let ambient temperature cool down the sensor between consecutive pictures.

Dithering with EAGLE CORE

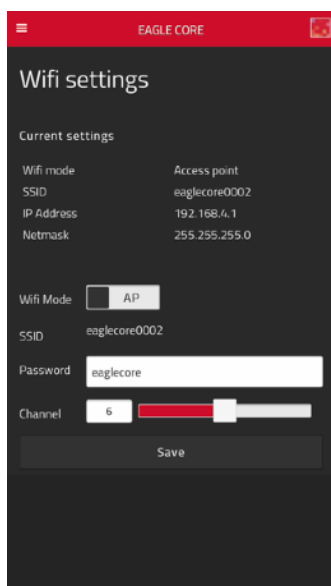
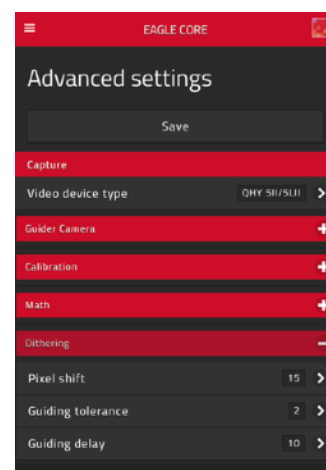


Dithering is an advanced technique designed to reduce background noise when stacking many images. In practice, the integration of the guide system with the image capture system makes it possible to move by a few pixels a picture with respect to the other and in a different direction for consecutive images. Since a particular form of background noise of DSLR and mirrorless cameras is static (ie it is constant in consecutive images), when you stack (and therefore re-align) the images recorded with Dithering and the images will be realigned by the software, the background noise will be misaligned between photos: this way when the images will be stacked, the noise of the sky background will be reduced. EAGLE CORE allows you to record pictures with the Automatic Dithering function. To activate it, press the "Dithering" button in the "Acquisition" tab.

We suggest to use Dithering when you want to record deep-sky images (galaxies, nebulas, star clusters) and at least 10 pictures.

It is also possible to adjust the advanced Dithering settings in the Advanced Settings menu. Here you can set:

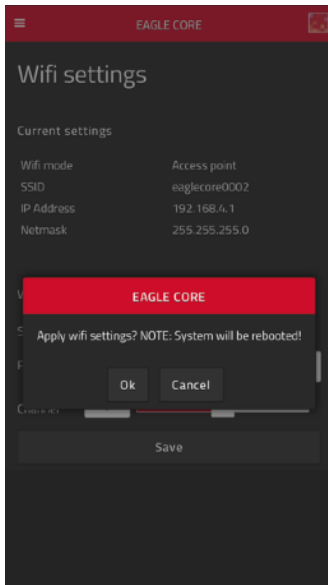
- **Pixel shift:** displacement in number of pixels between one image and the next.
- **Guiding tolerance:** distance in pixels above which the following image does not start.
- **Guiding delay:** time in seconds of delay between one image and the next one (a higher value helps stabilize the guide).



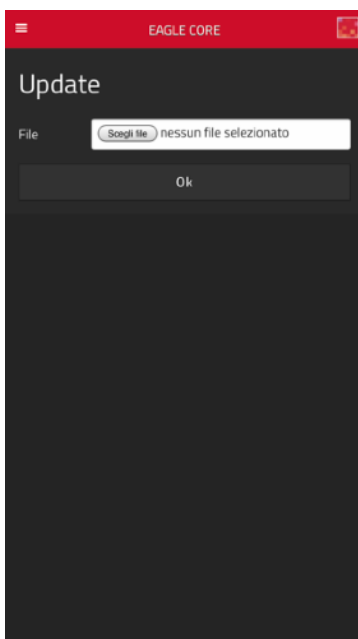
EAGLE CORE access password modification

In order to change the access password to EAGLE CORE from the settings menu you have to click on "Wifi settings", a new menu now appears in which the name of the SSID network is displayed (in this example EagleCore005) with the network password, which for the first use will be the default password "eaglecore". You can not change the name of the WiFi network created by EAGLE CORE, as each EAGLE CORE has its own unique network to avoid overlapping when there are more EAGLE CORE powered on on at the same time, for example during a star party. In order to change the password, simply click on the Password field and enter the new password. It is possible to change the EAGLE CORE transmission channel at the same time by moving the drag lever next to the "Channel" parameter. Press the "Save" button to confirm and a warning message will appear. By pressing the "ok" button, EAGLE CORE will emit an audible signal, and the "ACT" LED will be off. Before reconnecting, wait until EAGLE CORE emits another sound and the "ACT" LED is on again.

Now from the control device you will be asked to enter the new login password.



WARNING: If we changed to the wrong password or we forgot it, we need to connect to EAGLE CORE using a network cable connection and a computer, then we would be able to change the password. We suggest not to change the password on the field while we use the telescope to avoid any problem.

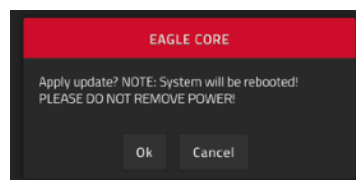


Updating EAGLE CORE

EAGLE CORE software updates can be downloaded from our website:

<https://www.primalucelab.com/astrometry/downloads>

Update files have .enc format. Download and save the file into the device you use to connect to EAGLE CORE, then go to the menu, click "Update" and open a page like the one you see in the picture, here you can select the installation file you saved on your control device and press The OK button. A confirmation prompt will appear: "Apply update? NOTE: System will be rebooted!" Confirm with OK, the ACT LED will be turned off and the system will be updated and restarted. **During the upgrade process you do not have to power off EAGLE CORE**, or EAGLE OS could be damaged irreparably. When the update is complete, EAGLE CORE will emit a sound and the ACT LED will turn on to confirm update and WiFi network creation.



WARNING:

- if you have an iOS device, please note EAGLE CORE update can be performed on devices with iOS operative system at least iOS11 version.

Control the computerized equatorial mount connected to EAGLE CORE

EAGLE CORE allows you to control computerized mounts (with WiFi and without the need to use the mount hand-pad) by directly connecting to one of the EAGLE CORE USB ports, by using SkySafari PLUS or PRO (<http://www.skysafariastronomy.com>) that you can download from the Store of your device. This feature is compatible with SkyWatcher/Orion with SynScan hand pad (tested with firmware version 4.39 or later) or Celestron mounts with NexStar hand pad.

In order to control your computerized mount with EAGLE CORE, follow this guide:

- When EAGLE CORE is powered off, connect all USB and power cables to EAGLE CORE. The mount must have the power button set to ON. If your mount has a serial connection cable (RS-232), you must convert it to a USB cable. To do this we recommend adding a special converter such as the ATEN UC232A.
- Connect the power to EAGLE CORE
- If you have a SkyWatcher mount (or if your mounts asks for Mode) select the Equatorial mode ("EQ Mode") by pressing the ENTER button.
- Follow the menu on your keypad to make a 1, 2 or 3-star alignment. **ATTENTION: to correctly control your mount with SkySafari you must enter the exact time and your geographical position (latitude and longitude) in the mount's hand pad.**
- Connect the device you use to control EAGLE CORE (for example your smartphone) to the EAGLE CORE WiFi network.
- Start SkySafari PLUS or PRO, then select SETTINGS and SETUP.
- In the window that opens, insert these settings:
 - Scope Type: your mount
 - Mount Type: Equatorial GoTo
 - Autodetect SkyFi: OFF
 - IP Address: 192.168.4.1
 - Port Number: 4040
 - Set Time & Location: ON
 Then click "Done" in top-right to save.
- Click the "Scope" button and then "Connect" (if an error message appears, press the Connect button again).
- SkySafari will show the position of your telescope corresponding to the last star you used to align your mount. Now you can control your mount from your device via WiFi and EAGLE CORE.
- The arrow buttons (on the left and right of the main screen) allow you to move the mount like the buttons on the physical hand pad of your mount, setting the movement speed displayed below: 1 (minimum), 2, 3 or 4 (maximum).

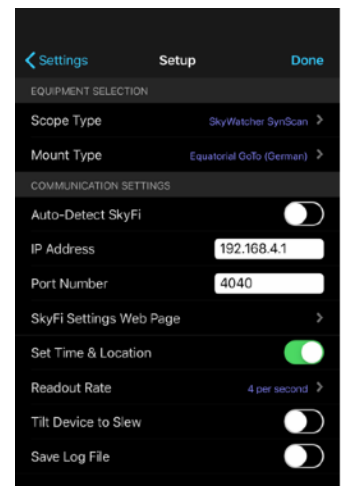


image courtesy of [SkySafariAstronomy.com](http://www.skysafariastronomy.com)



image courtesy of [SkySafariAstronomy.com](http://www.skysafariastronomy.com)

- You can use SkySafari to find, view and point objects in the sky. You can also get a preview of the area framed in the sky based on the focal length of your telescope and the type of sensor you use. In order to do this press the "Observe" button and then click on Equipment. In the window that opens you can insert your telescope (TELESCOPES) with diameter and focal length. Then you can enter your camera (CAMERAS) with resolution and pixel size. Click "Done" at the top right when you are done.
- Now click "Observe" and then "Scope Display". In the window that opens click the "Add FOV Indicator" button. In the window that opens, select your telescope, your camera and, if you have previously added a focal reducer or multiplier, add this option as well. Click the "Done" button at the top right to confirm. In this way SkySafari will calculate the real field framed by your telescope and camera, showing it on the sky chart.
- You will be able to verify if the field is sufficient to photograph the whole object. In the image below: not enough on the left, excellent on the right.



image courtesy of SkySafariAstronomy.com

- In order to point an object, you can select it among the many objects shown in SkySafari (you can click on the stars, planets, galaxies, nebulae or star clusters) and then click the GoTo button. The mount will move to the requested object.
- Now you can move to the EAGLE App to control camera, focus, autoguide and record your pictures.

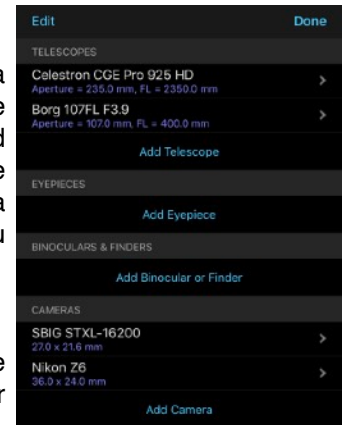


image courtesy of SkySafariAstronomy.com

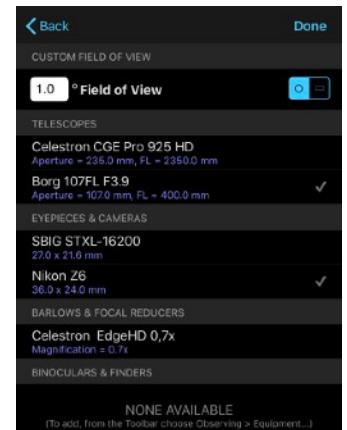


image courtesy of SkySafariAstronomy.com



image courtesy of SkySafariAstronomy.com

Install EAGLE CORE on a telescope or use with a telephoto lens

TIP 1:

If, after pointing an object, in the EAGLE App you notice that it is not pointed at the center of your camera sensor, you can move the telescope with the arrows in SkySafari until you bring it to the center of the field of view, then press the "Align" button in SkySafari. In this way the actual position of your telescope will be synchronized with the sky map.

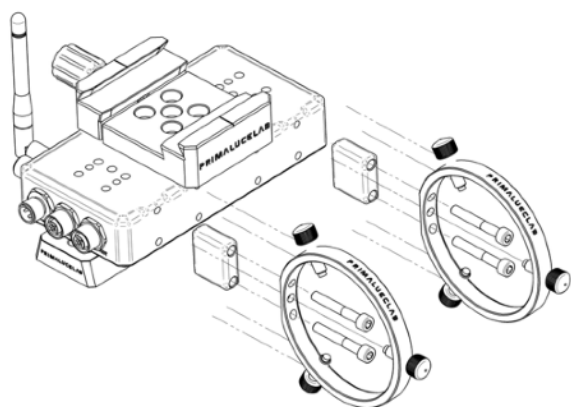
TIP 2:

If you notice that, after having performed the polar alignment of the mount and the alignment on the stars, the pointing of the object is not precise (for example if you don't frame it in the field of your camera) you probably have a wrong polar alignment or you have inserted some wrong data in your mount or in SkySafari: check them again before proceeding.

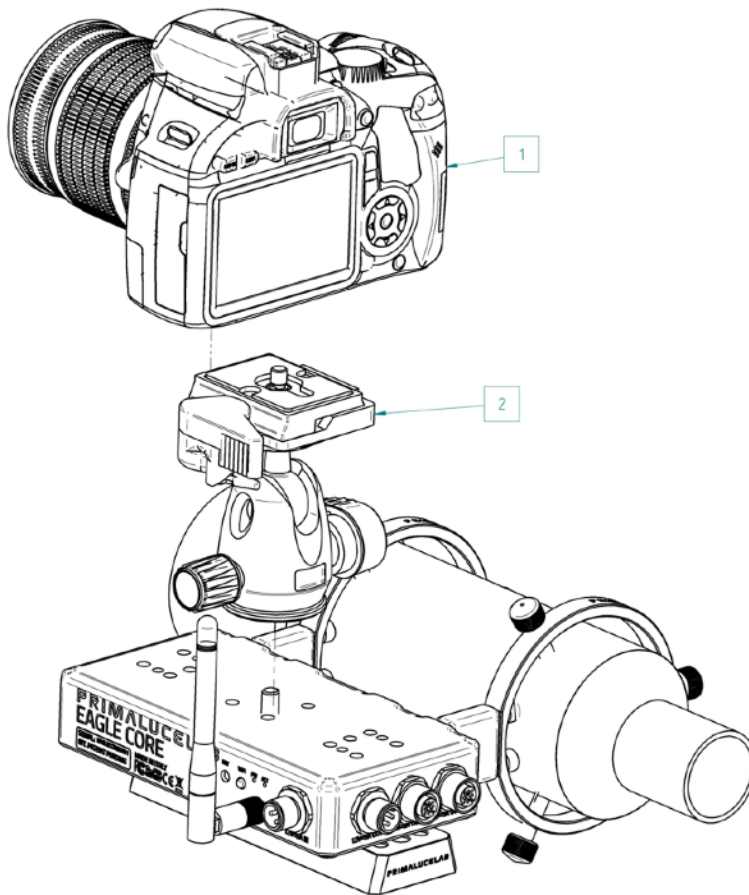
EAGLE CORE has been entirely designed with SolidEdge three-dimensional design software to offer the widest possible modularity along with PLUS elements (dovetail plates, rings or clamps) and/or with telescopes from many brands. EAGLE CORE can be positioned under a camera lens, between support rings and guide rings, connected to a Vixen or Losmandy type plate using the optional clamp or, in the case of telescopes with long bars, it can be screwed on the PLUS Vixen or Losmandy plate to be placed on top of the PLUS support rings. So let's see the various configurations possible, depending on the telescope on which EAGLE CORE is installed, either using other PLUS elements or with different instruments, or using the telephoto lens of your camera.

WARNING: in order to connect EAGLE CORE to other PLUS mechanical elements, do not use longer screws than M6x12 and M5x12. Otherwise, the screws could touch the EAGLE CORE internal elements and could lead to breaks or malfunctions. Screws are supplied with EAGLE CORE.

Connection to camera with telephoto lens.



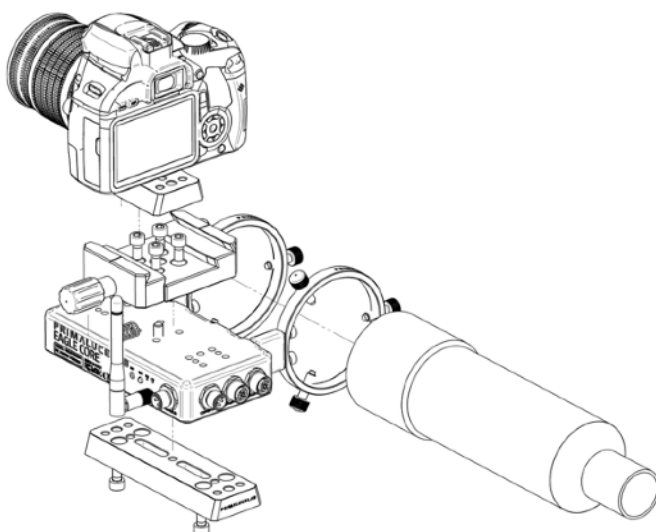
If you do not have a telescope you can do astrophotography even using the telephoto lens of your camera. In this case, EAGLE CORE can be installed as the support of your camera with telephoto lens just as if it was a bar. In this case, connect a 140mm Vixen PLUS bar under EAGLE CORE using two M6x12 screws (supplied); then install the optional 80mm PLUS guide rings next to EAGLE CORE using the optional spacers and the M5X40 screws (optional). *Warning: in order to avoid any flexure, the guide telescope must not exceed 3 Kg weight.* In order to install the camera above EAGLE CORE you have two options:



A. Screw a photographic ball head (not included in the package) to the photographic screw on the EAGLE CORE case and then connect the camera with a lens above the photo head.

- 1) Camera with lens
- 2) Ball head

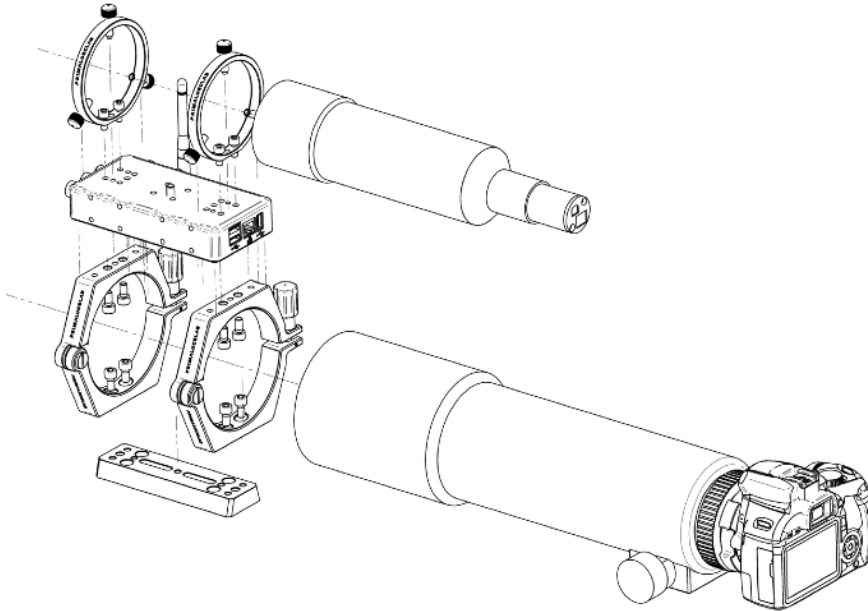
B. If you want more stability (recommended when using heavy telephoto lenses, for example with focal lengths greater than 100mm), screw the Vixen+Losmandy PLUS dovetail clamp on EAGLE CORE. Then connect the 90mm PLUS Vixen bar underneath the camera (or underneath the support found on some heavy photographic telephoto lenses). You can then place the camera on EAGLE CORE, having a rigid and quick-locking mechanism.



- 1) M6x12 screw
- 2) Vixen or Losmandy bar
- 3) Vixen/Losmandy PLUS dovetail clamp
- 4) 80mm PLUS guide rings with spacers
- 5) 60mm guide telescope
- 6) 80mm Vixen PLUS bar

Connection to telescopes with PLUS support rings (spaced up to 12cm)

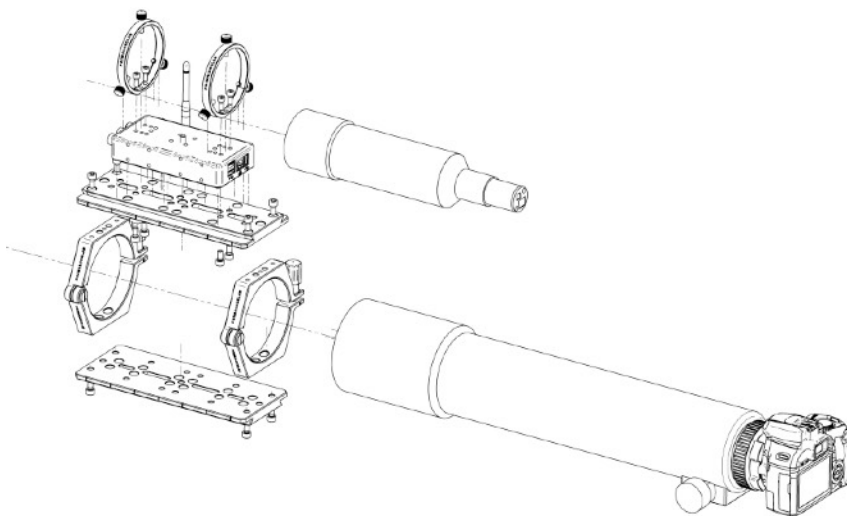
Using compact apochromatic telescopes, the distance between the support rings is given by the Vixen or Losmandy PLUS plate installed under the telescope. In this case, EAGLE CORE can be installed directly above the support rings, just as if it were a bar. With the special M5 threaded holes on top of EAGLE CORE, then you can install PLUS guide rings and then a guide telescope (warning: the guide telescope should not exceed 3 Kg in weight to avoid flexures).



In order to use EAGLE CORE in this configuration, insert 2 M6x12 screws into each PLUS ring (2 screws for every ring) and fasten EAGLE CORE. So if you want to use a guide telescope in parallel, you can fasten the PLUS guide rings to the top of EAGLE CORE by screwing, for each ring, 2 M5x12 screws.

Connection to telescopes with PLUS support rings (spaced more than 12cm)

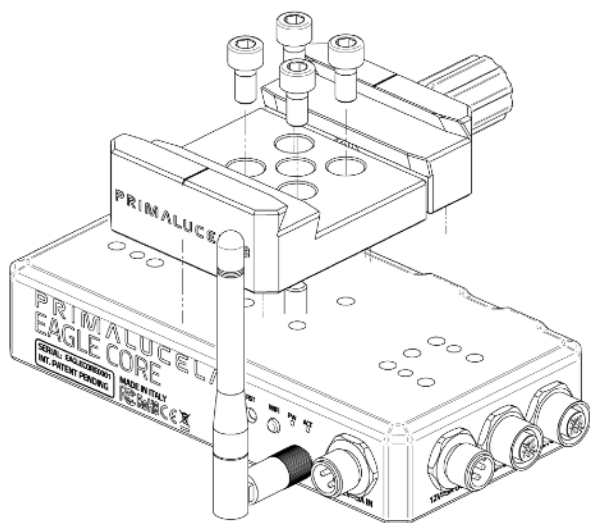
If you want to use EAGLE CORE with telescopes with PLUS rings spaced more than 12 cm, you can place EAGLE CORE above the support rings to support a compact telescope in parallel. In order to do this, however, you must first add a Vixen or Losmandy PLUS plate on top of the support rings and then install EAGLE CORE.



In order to use EAGLE CORE in this configuration, place a Vixen or Losmandy PLUS plate (same length as the one placed under the support rings) and secure it with 2 M6x12 screws for each ring. The plate above the telescope must be inverted to the position beneath the optical tube. Then use 4 M6x12 screws to secure EAGLE CORE to the plate. Finally, if you want to use a parallel telescope, you can connect the PLUS guide rings. In order to do this, screw 2 M5x12 screws for each guide ring at the top of EAGLE CORE.

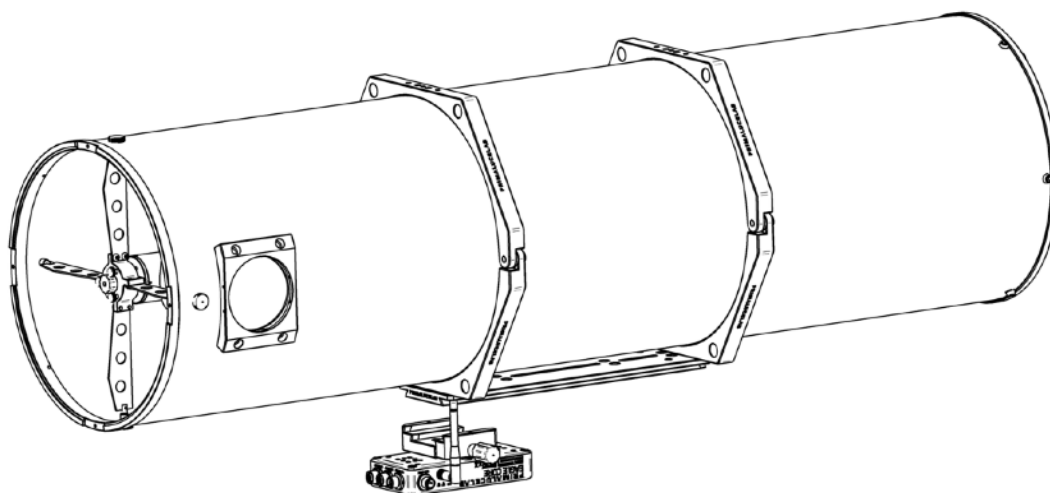
Connection to telescopes without PLUS support rings

If your telescope does not have PLUS support rings, just add the "PLUS Vixen+Losmandy dovetail clamp" and screw it directly to EAGLE CORE to allow you to connect it any Vixen or Losmandy dovetail bar.



Take the "PLUS Vixen+Losmandy dovetail clamp" and use 4 M6x12 screws to secure it to EAGLE CORE, as shown in the image.

This way you can connect it to any telescope equipped with a Vixen or Losmandy dovetail bar as shown in the next page image.

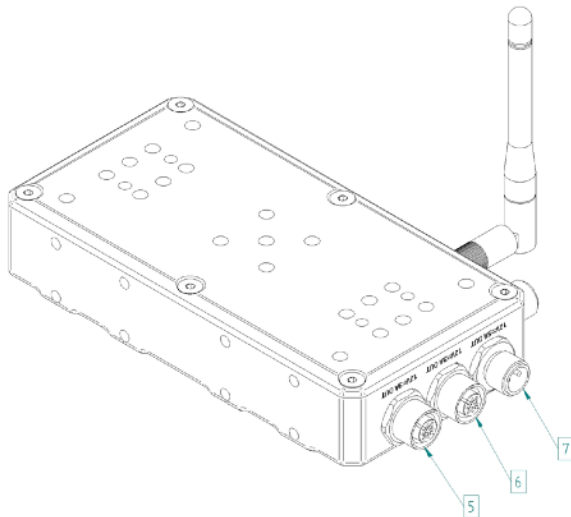


Power other instruments through EAGLE CORE

EAGLE CORE incorporates a power bridge that can be used to connect up to 3 instruments such as mount, camera and electronic focuser avoiding the need for other power supply sources and reducing the number and length of cables. Through a special internal board, EAGLE CORE **distributes** 12V power to the 3 ports to which the various devices are connected via the optional cables. All power ports are equipped with a safety screw socket to prevent the cable from being inadvertently disconnected or polarity reversals. 2 power outlets have a resettable 3 Amp fuse each while one port has a resettable 5 Amp protection fuse and is specially designed for connecting to cooled DSLR cameras that often have high power consumption.

WARNING: EAGLE CORE distributes 12V power only. If the instrument you want to use requires a different voltage, **DO NOT** connect it to the EAGLE CORE power ports.

WARNING: the power OUT ports of the EAGLE CORE depends on the power supply or the battery connected to the power IN port of EAGLE CORE. **Since various astronomy instruments require strictly 12V fixed power supply, you need to check that your power source supplies a stable 12V voltage.** If you want to power EAGLE CORE with a battery, make sure it is equipped with a special 12V voltage stabilizer. **DO NOT CONNECT TO EAGLE CORE A BATTERY WITHOUT VOLTAGE STABILIZER** as it may damage other instruments powered through EAGLE CORE.



EAGLE CORE has 3 12V power out ports:

- Plugs 5 and 6 have a resettable 3 Amp protection fuse and are used for connection to mounts and other instruments (with power consumption up to 3A), port 7 has a resettable 5 Ampere protection fuse and is used to connect instruments that need more power (such as cooled DSLRs). To avoid confusing the power out ports, the 3A ports have a different connector than the 5A one.

WHAT HAPPENS IF I CONNECT AN INSTRUMENT THAT NEEDS MORE CURRENT THAN THE ONE ACCEPTED BY EAGLE CORE OUTPUTS? The internal power board has special protection fuses. If your device requires more power than the one distributed by EAGLE CORE, the fuse blocks the port (this is a security feature to avoid current rushes that could damage the connected instrument). **When you remove the power cable, the port is automatically reset.**

To properly power all peripherals through EAGLE CORE:

- 1) **BEFORE** connect the EAGLE-compatible (optional) power cables to the EAGLE CORE power OUT ports and then to the power port of your device
- 2) **AFTER** connect the power supply or stabilized battery to the EAGLE CORE power in port

All instruments will be powered. Once powered, EAGLE CORE will turn on and you can turn on remote control and use the telescope. When you want to turn off the telescope, follow this procedure:

- 1) **BEFORE** disconnect power from the EAGLE CORE (you don't need to make a shutdown in the same way you do with a Windows computer) by disconnecting the power cable from the power IN port of EAGLE CORE
- 2) **THEN** disconnect the power cables from the 3 power OUT ports of EAGLE CORE

If for some reason you can no longer access EAGLE CORE via Wi-Fi, you can reset the Wi-Fi network by holding down the Wi-Fi button on the EAGLE CORE for about 10". EAGLE CORE emits 3 sound signals in sequence and starts the Wi-Fi network again without interrupting the autoguide or acquisition operations. If this function does not work, it is possible to press the reset button RST, in this case EAGLE CORE is forced to restart, while all the devices powered by EAGLE CORE remain powered.

Introduction to astrophotography with DSLR and mirrorless cameras

Modern DSLR or mirrorless cameras have low cost, offer large sensors and generally have low electronic noise even with the typical astrophotography exposition times: they are therefore perfect to take pictures of Universe's objects, recording weak details, even invisible to the naked eye. But the camera is not enough: because of the Earth's rotation motion, objects in the sky continuously move and, in order to record the best images (which often needs many minutes of exposition time), we need an high performance tracking system (**mount**) that tracks the apparent movement of objects in the sky and thus allow us to keep the camera shutter opened. Modern mounts are also **computerized** and thus allow to automatically slew to many objects and can be used in conjunction with **autoguide systems** that, automatically adjusting even the smallest mount tracking errors, allow to record images even with very long exposition times keeping the stars perfectly tracked. EAGLE CORE allows you to control these systems and, in a simple and fast way, record images through a DSLR or mirrorless camera, commanding the entire setup through a smartphone or tablet.

Planetary/lunar and deep-sky astrophotography

Objects to image in the sky are obviously not equal and, above all, they have both apparent sky dimensions and brightness very different. For this reason, when we speak of astronomical photography, we usually divide it into:

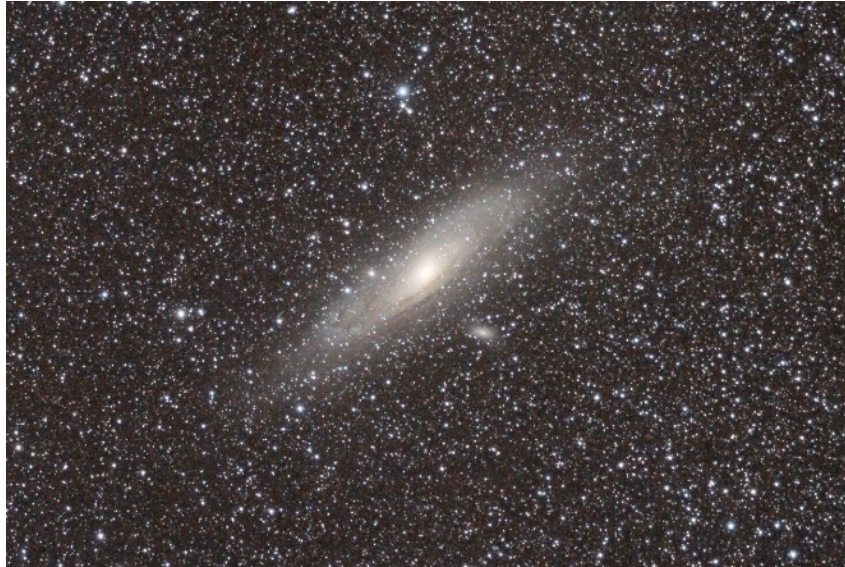
- **planetary/lunar photography**
- **deep-sky photography**

The first is performed by recording planets and the Moon usually at high magnifications (except when we want to record the entire lunar surface in the same picture). Since the recorded objects have a high surface brightness, shutter speeds required for this kind of imaging are generally low (even fractions of second) and the autoguide is not necessary (since the automatic tracking feature is sufficient to track the expositions correctly).



Moon recorded with apochromatic refractor, Nikon D5600 DSLR and EAGLE CORE

Deep-sky astrophotography is performed on nebulae, star clusters, and galaxies that always have a very low brightness and that, sometimes, may have large apparent dimensions in the sky (even larger than the Full Moon size). For this reason, they can be photographed not only with telescopes but also with telephoto lenses and always require very long exposition times. In this case, the use of autoguide (page 96) is essential to keeping the stars perfectly tracked in the picture.

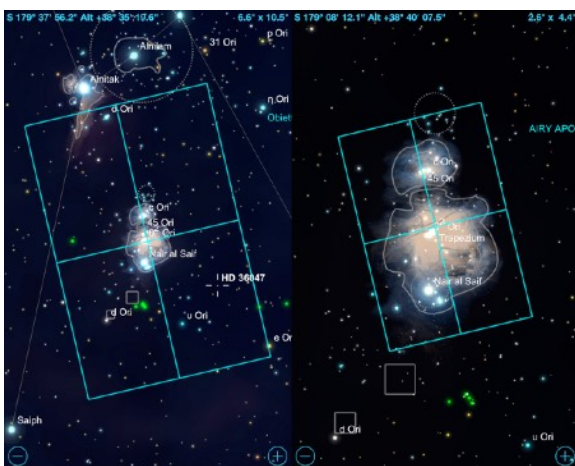


M31 galaxy with Canon EOS 7D, 200mm f/4 telephoto lens and EAGLE CORE , sum of 6 pictures 300s each

Astrophotography with telephoto lens or telescope?

EAGLE CORE is designed to allow you to record pictures both with telephoto lens and telescopes. In fact, despite a telescope is usually recommended since it generally has a greater focal length than photographic lenses and it has an objective that can be specially designed for astrophotography, performing astrophotography with photographic lenses is a great way to start imaging the night sky. Having made the first experiences, you can buy a real telescope and EAGLE CORE will be ready for its use. For this reason, you can use EAGLE CORE to record with the camera and photo lenses or with the telescope. Of course, the use of a larger telescope allows you to gain greater magnification and greater resolution capability. However, having longer focal length, you have to keep in mind that:

- 1) the mount will have to be more stable and precise, and therefore generally more expensive. You will also need to make a more precise polar alignment of the mount (page 91) to minimize tracking errors.
- 2) the field framed by the camera sensor will be smaller so some very large objects in the sky (like the Andromeda Galaxy) could be better reproduced with a telephoto lens than a telescope (which could frame only one part).

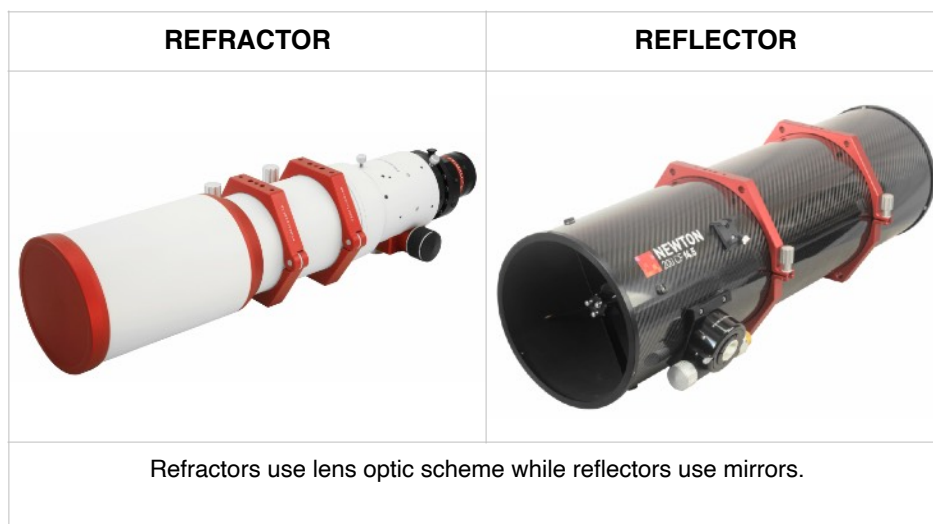


Magnification and framed field comparison with a 200mm telephoto lens (left) and 650mm focal length telescope (right) with the same size APS-C sensor.

(simulated with SkySafari, courtesy Simulation Curriculum)

If you want to take pictures with a photographic lens, you can usually record the sky with a focal length between 35mm and 300mm. Of course, the more "open" the better the objective is, because it allows you to record weaker details, using the same exposition time. However, it is good to close at least one stop for the lens diaphragm (so if you have a f2.8 you can close it at about f3.5) to increase the natural contrast of the image and get more pointing stars close to the edge of the framed field.

If you want to record the night sky through a telescope, you should consider that the telescopes are not all the same: they can use different optical schemes and therefore have different performances in various application fields. Generally telescopes are divided into **reflectors** if they use mirror optics or **refractors** if they use lenses.



The latter are the models most used in long exposure astrophotography of deep-sky objects because they combine high performance with a compact size (so they can be easily transported in search of low light polluted skies) and a high ease of use (since, almost always, they do not require to be collimated as for reflectors). In particular, the most used refractors in astrophotography are the **apochromats** that provide a perfect chromatic correction, even better than the one offered by a photographic lens. This performance is achieved thanks to the high quality of ED lenses and to the lower number of lenses used than photographic lenses (telescopes have fixed focal length and do not allow the aperture to be selected in diaphragm, always working at maximum aperture).

Choosing the telescope for long exposure astrophotography of deep-sky objects, we must also pay attention to the focal length of the telescope: the lower it is, the simpler it will be to record the weaker details of nebulae or galaxies. For this reason, we suggest to avoid focal ratios longer than f/8. Optimal telescopes have focal ratios from f/5 or f/6. Too low values are not always recommended since, having lower focal lengths, they would not be good to record details of many small objects.

Using a telescope with DSLR cameras (which have large sensors), the telescope has also to be "flat", ie offering perfectly point stars throughout the field (which would otherwise appear as small comets). This is achieved by using optical accessories (**field flatteners** for refractors, **coma correctors** for Newton reflectors, etc). The correct declared field of the telescope must therefore be at least 27mm in diameter to correct an APS-C or DX type sensor and 44mm to correct a Full Frame or FX sensor. Field flatteners vary by telescope since they must be specially designed for the optics they correct.

Mount and sky objects tracking

As we have previously mentioned, in order to record pictures of the night sky with telescopes or telephoto lenses it is essential to have an automatic tracking system of the apparent movement of stars in the sky: the **mount**. This, acting as if it were a "motorized tripod", allows us to leave the camera shutter even open for long exposures tracking the object to be photographed: the result we want to get is a photo with a precise tracking and stars perfectly point shaped throughout the field. In general telescope mounts are divided into:

- **altazimuthal**: the telescope movement is on 2 axes, high-low and right-left, as with a common photo tripod.
- **equatorial**: The movement of the telescope is around one axis (polar axis) of the mount which is set in an inclined position and which must be pointing towards the Sky Pole (in northern hemisphere, a point in the sky very close to the Polar Star).

Equatorial mounts are more complicated to use since, when used, require to perform the **polar alignment** (and since the tracking quality of the mount is proportional to the polar alignment accuracy, it is essential to perform this procedure precisely) and, to install the telescope, heavy counterweights must be used. However, the equatorial mounts, moving the telescope around an axis corresponding to the rotation of the sky, offer greater tracking precision and are therefore usually used for astrophotography.

Choosing the mount to use depends especially on the optical tube that it has to support. In fact, various mounts offer different load capacities, that is, the maximum weight of the optical tube that they can support. For example, mounts that have 7-8Kg load capacity are common, while higher-end ones can support 25Kg optical tubes. Choosing the mount, be aware that the load capacity is intended for visual use while for the photographic one it is necessary to divide the maximum load for 2. This is because the astrophotography use (especially with long expositions) requires a perfect mount stability. For example, in the case of a 4 kg apochromatic refractor, for photographic application you can choose a mount with 10Kg of load capacity (5Kg photographic).

In the choice of the best mount for astrophotography, it is also necessary to consider the focal length of the telescope and then the magnification factor created by the optical tube. Obviously, the more the telescope focal length, the higher the magnification will be, so we can record smaller details. However, greater magnification also requires a better tracking precision, a parameter we must consider as equatorial mounts are not all equal and do not offer all the same tracking precision. In general, when the focal length does not exceed 1000mm, commercial mounts with good mechanical construction are enough also for long expositions usually required in deep-sky astrophotography. When focal lengths exceed 1000-1500mm, things get complicated and you need high-end mounts that are generally very expensive. This is one of the reasons (in addition to the high optical quality) that, starting in astrophotography, we suggest to use an apochromatic refractor: in fact, regardless of diameter, an apochromatic refractor hardly has a focal length longer than 1000mm and therefore it allows you to use equatorial mounts that are not too expensive.



Connecting DSLR or mirrorless camera to telescopes

When we want to use a telescope to do astrophotography, we can connect the camera in various ways, thus getting different magnification capabilities:

- **prime focus photography:** the camera body is directly connected to the telescope that is used as a powerful telephoto lens. So if the telescope, for example, is a 80mm diameter refractor and 500mm focal length, we will use it as a 500mm f6.25 telephoto lens. This type of use is usually applied to long exposure astrophotography of galaxies, star clusters and nebulae, or in the low-magnification planetary/Moon one (for example, to photograph the entire lunar surface as seen on page 83). The type of accessory required for prime focus photography depends on the type of telescope we are connecting the camera to (so you have to read the telescope manual before) but, if we consider the refractor telescopes, it is usually made with 2 accessories:

1- T2 or M48 ring that, connected in front of the camera body instead of the photo lens, converts the brand bayonet into an universal 42x0,75 (T2) or 48x0,75 (M48) thread.

2- T2-50,8mm photographic adapter (or M48-50,8mm based on the ring previously used) that, threaded to T2 ring, allows you to connect the camera to any telescope focuser (that usually has 50,8mm diameter)

Instead of the T2-50.8mm photo adapter, you can use a **field flattener** (or coma corrector) that does not change the telescope focus. Some telescopes also offer dedicated **focal reducers** which, by reducing the focal length of the telescope, also reduce the focal point and thus make it more "fast", making it easier to capture weak objects. It should always be considered, however, that reducing the focal length of the telescope reduces the magnification generated and thus also the resolution capacity of the telescope. So the use of a focal reducer is not always the best solution for astrophotography.



Nikon DSLR camera connected in prime focus (with field flattener) to apochromatic refractor: this way it uses the telescope as a 650mm (f6.25) telephoto lens

- **projection photography:** using special adapters, we use an optic element (which can be an *eyepiece* or a *Barlow lens*) between the camera and the telescope, and this is used to multiply the focal length and thus the magnification generated by the telescope. This way, you can get images of lunar details (such as craters) and planets of the Solar System. It should be considered that increasing the magnification, the focal ratio of the telescope will also increase (for example, from f/6 to f/20) and therefore this technique is not suitable for recording weak objects with long expositions.



Nikon DSLR camera connected with projection (with 3x Barlow lens) to apochromatic refractor: this way we use it at 650mm x 3 = 1950mm focal length (f18.75)

Before starting to photograph: light pollution and power

Before we start we must make two considerations.

Light pollution: Even if you can use the telescope anywhere, it is always better to move looking for low light polluted areas. In fact, using the same exposition time, photographing from a place that has a lot of light pollution will generate an image in which the sky background will be bright and it will hide the signal of the weaker galaxies, nebulae or star clusters we want to photograph. Therefore, even if there are special filters against light pollution that reduce this problem keeping the sky background as dark as possible, we always recommend taking pictures from dark skies. If you live in the country you probably already have a good sky, but if you live in the city, bring the telescope in the car and move to the darker areas, you will get better results!

Telescope power: when we consider an astrophotography telescope, we talk of an instrument composed by different parts that need to be powered. Unless you have an observatory equipped with special power plugs, we will need a battery to power all the elements such as the mount or other accessories. EAGLE CORE allows us to power all the components of the telescope very efficiently but still requires a 12V stabilized battery that has a capacity of many Amps to keep the entire telescope powered for all the imaging duration. Considering a mid-size mount and to power the DSLR camera via the optional EAGLE power supplies we have:

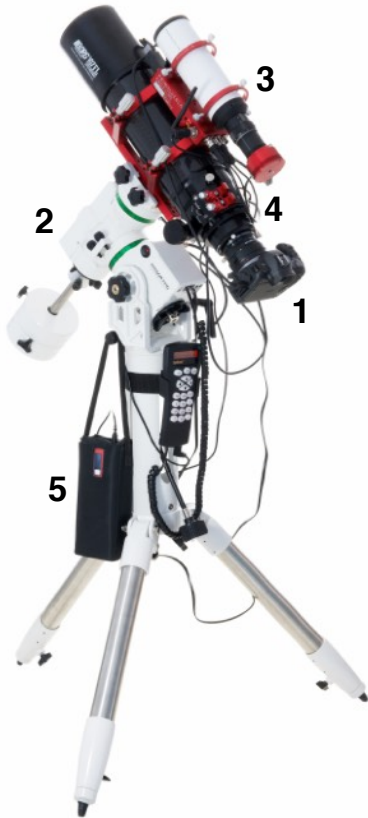
$$\text{Mount (1000 mAh) + EAGLE CORE (250 mAh) + camera (350 mAh) = 1600 mAh}$$

So we have an average consumption of 1.6Ah which, for a duration of 8 hours (considering the average duration of the night), requires at least a 12V 13A battery.

ATTENTION: since EAGLE CORE can control up to 4 devices and it has 3 USB ports, if you have 4 devices you will need to add a USB hub (2 ports USB hub).

Astrophotography with EAGLE CORE, step-by-step guide

An astrophotography telescope is therefore composed of many elements that can be controlled and powered by EAGLE CORE. In order to do this, all devices (DSLR or mirrorless camera, autoguide camera, SESTO SENSO and mount) must be connected to the EAGLE CORE USB ports. If devices (such as for example the mount) require a 12V power supply, they can also be powered through EAGLE CORE using the optional EAGLE power cables.



An example of a complete telescope for astrophotography with EAGLE CORE is shown in this image. It is composed by:

- 1) *refractor with DSLR or mirrorless camera* (connected to the USB port of the EAGLE CORE)
- 2) *equatorial mount* (connected to USB and power port of the port EAGLE CORE)
- 3) *telescopio guida con camera di guida* (connected to the USB port of the EAGLE CORE and to ST4 port of the mount)
- 4) *messa a fuoco con SESTO SENSO* (connected to USB and power port of the port EAGLE CORE)
- 5) *12V battery* that powers EAGLE CORE and all the devices powered through it.

Having the telescope under the sky and connected all the elements as we have seen before, we can begin to record images with EAGLE CORE and your camera. Follow these steps:

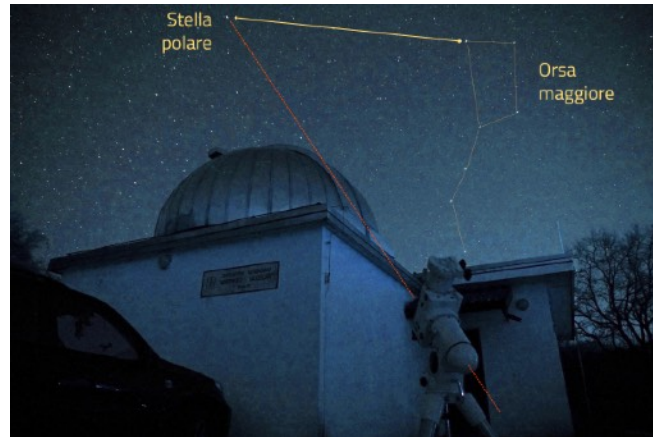
- 1) align the mount to Pole
- 2) align the mount to the stars
- 3) point the object to record
- 4) focus DSLR or mirrorless camera
- 5) start autoguide
- 6) advanced autoguide settings (optional)
- 7) record pictures with DSLR or mirrorless camera

Step 1: align the mount to Pole

The aspect to take care of in field use is the polar alignment of the mount. As already written in one of the previous paragraphs, equatorial mounts have an inclined rotation axis that needs to be adjusted to match the one of Earth. To do this, first place the tripod that supports the head of the mount in horizontal position. Most equatorial mounts have a bubble to adjust the length of each leg and reach the horizontal level.



Then look at the sky and look for the position of the Pole Star that indicate the geographic north direction and that is the direction to point the polar axis of the mount to (in the picture shown by the dashed line). If you do not know where it is, you can search for the Big Bear constellation (often known as the Ursa Major): prolong about five times the joining of the two stars as shown in the image and you will find the Pole Star. Point the mount towards the direction of the Polar Star and, if necessary, always check that the bubble indicates the horizontal position.



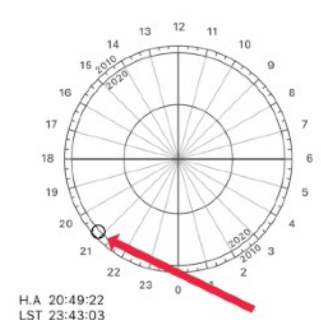
Pole Star position in respect of the Big Bear

Then use the polar scope integrated in the mount to precisely point not only the Pole Star but the true position of the Pole, using the special crosshair incorporated in the polar scope (each mount has a different crosshair so there are various procedures to perfectly adjust the alignment, always listed in the manual of the mount itself).



Use the polar scope of the mount for a precise polar alignment

Pole Star doesn't coincide perfectly with the position of the North Pole, so it's possible to further improve the polar alignment precision using various methods that vary according to the mount. In order to have an help, we can use some dedicated apps like PolarAlign (which you can download for iOS or Android from their Stores) that show the polar star's theoretical position relative to the mount crosshair according to the observation date and time. Observe the Pole Star in the polar scope of the mount and, using the azimuth and latitude settings of the mount itself, set the Pole Star position as displayed in the app (in the image, the Pole Star must be positioned where indicated by the arrow). By positioning the Pole Star in the indicated position, the mount will point to the real celestial pole and thus will offer better tracking precision.



Step 2: align the mount to the stars

Let's move on the alignment of the mount on the stars, which is fundamental when using a computerized mount with automatic Goto feature. This step is needed to align the mount to the objects in the sky (depending on the date, time and place from which we photograph) and allow us to automatically point to one of the many objects in the sky in the mount database. As with polar alignment, each mount has a different procedure so please read the manual that came with the mount.

Generally, after turning on the mount, you will be asked for the date, time and place of observation. Then you will be prompted to align to the stars and, using the "Acquisition" tab and activating the "Start focus loop" feature (or "Preview" if you use SESTO SENSO), you can use EAGLE CORE to see the image in real time on your smartphone or tablet and check the alignment to the stars.



By observing the real time image in your smartphone or tablet, you can set the telescope focus and align the mount.

Step 3: point the object to record

Now you can point the object you want to photograph. If you are using a computerized mount, you can point the object using the arrow keys on the mount handpad or you can connect mount's handpad to one of the USB ports of the EAGLE CORE and control the mount with SkySafari PLUS or PRO (as previously described). As for step 2, each mount has a different procedure so please read the manual that came with the mount itself.

If the object to be photographed is weak (such as a nebula, a galaxy or a stellar cluster), before pointing it we recommend that you point a bright star to focus (step 4).

Step 4: focus DSLR or mirrorless camera

After pointing the telescope or telephoto lens to a bright object (such as a star, planet or moon), select the "Acquisition" tab of the EAGLE CORE App. Then set a relatively short exposition time (for example 1 second), high camera ISO sensitivity (eg 1600 or 3200 ISO) and click "Start focus loop" to make the camera shut in loop mode. Use the telescope focuser or the manual focus of the telephoto lens to adjust the focus as long as you see the stars as points on the screen of your control device. For precision focus you can also zoom in on the display of your smartphone or tablet, and then fine-tune the focus. When the star appears perfectly in focus, click on the "Stop focus loop" button.

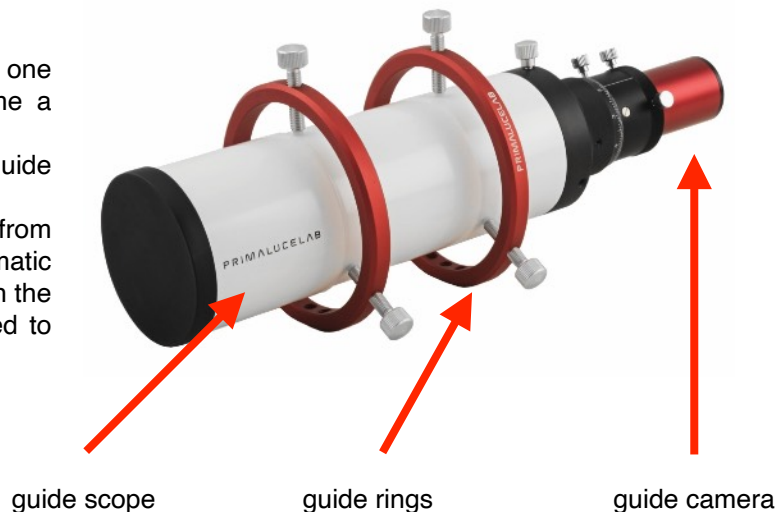
If instead you use SESTO SENSO, press the "Preview" button to preview the first image. Then move the focuser with the appropriate buttons (or with the slider) and EAGLE CORE will automatically perform a new image.

Images displayed on your smartphone or tablet have the maximum resolution of your camera to allow you to focus more accurately. During the focusing process, EAGLE CORE does not save any image on the camera memory card.

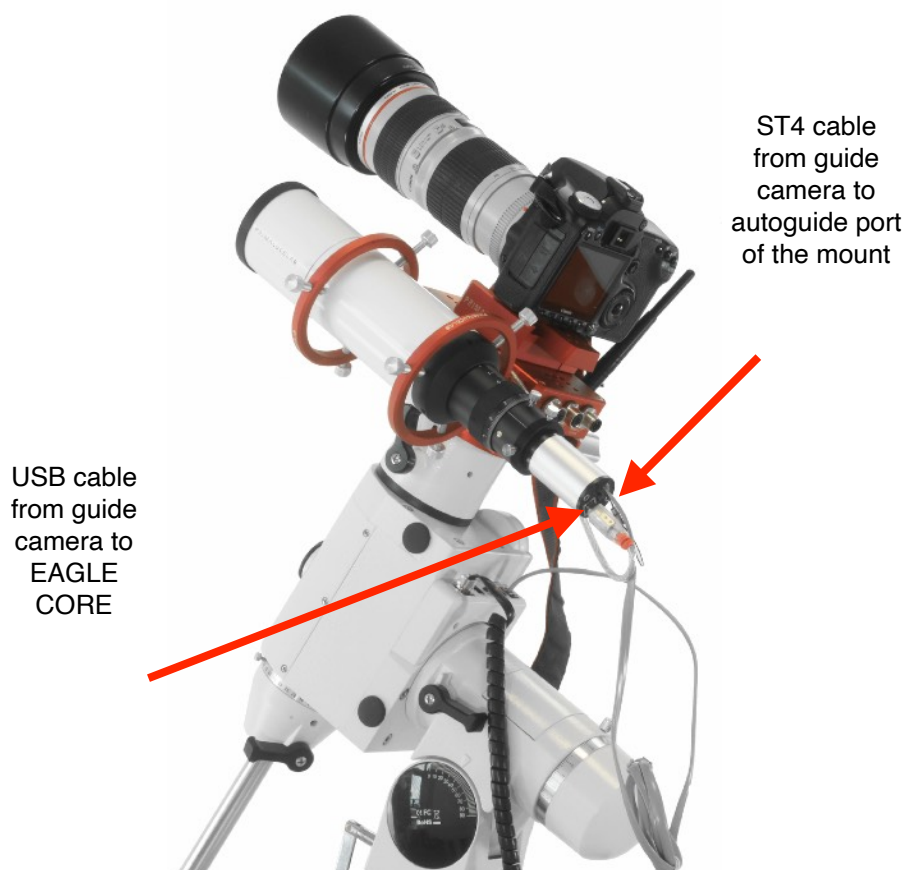
Step 5: start the autoguide

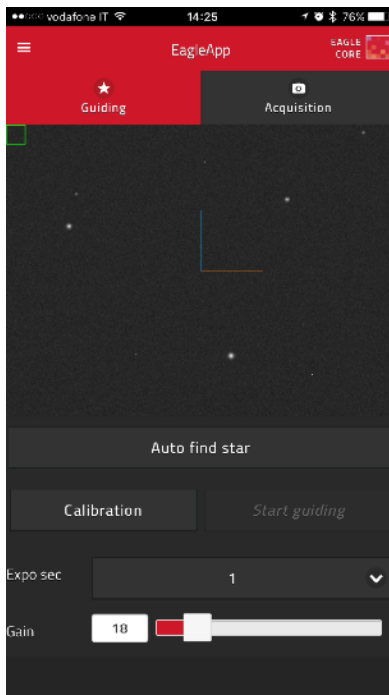
Equatorial mounts, also if accurate, can show some sort of tracking error that, if you want to photograph deep-sky objects such as galaxies, nebulae or star clusters and therefore you need to perform long exposures, can lead to elongated stars and thus ruin the images. For this reason, photographing deep-sky objects, the **autoguide** technique is used to automatically correct these errors. The autoguide system consists of 3 elements:

- **guide scope**: installed in parallel to the main one (or to the telephoto lens) it's needed to frame a guide star
- **autoguide camera**: capture the light of the guide scope and sends it to the autoguide software
- **autoguide software**: elaborates the signal from the autoguide camera and sends the automatic position correction signal to the mount through the ST4 port of the autoguide camera, connected to the ST4 port of the mount by a special cable.



EAGLE CORE includes autoguide software and allows you to connect the guide scope, using 80mm PLUS guide rings (optional), both on top (when EAGLE CORE is used with a telescope) and on the side (when EAGLE CORE is used together with a telephoto lens).

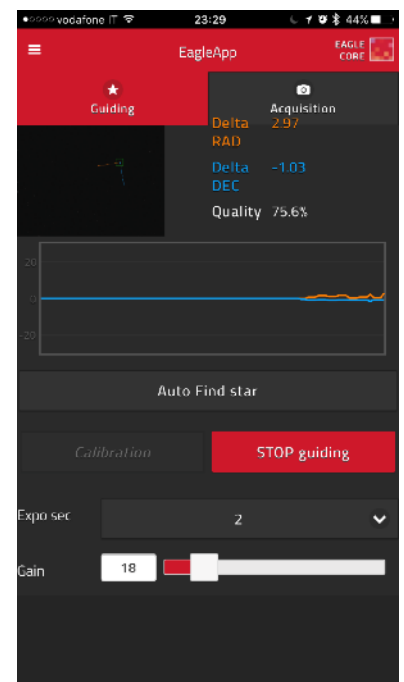




Connect the guide system on top or on the side of EAGLE CORE (depending on the photography mode you are using). Then insert the guide camera into the guide telescope. Behind the guide camera there are 2 ports: one USB and one autoguide ST4. Insert the USB cable into the USB port of the camera and then connect it to one of the EAGLE CORE USB ports. Then take the ST4 guide cable and insert it from one side into the ST4 port of the guide camera, on the other in the autoguide port of the mount.

Having set your recording system and activated the mount, point the telescope or the photo lens toward the sky and select the Guiding tab. You will thus observe the image captured by the guide camera in real time and, by manually moving the focus of the guide scope, focus the stars until they appear as point on the screen of your device. Now "tap" on one of the stars in the field (if you do not see any stars, you can act on the guide rings screws to slightly move the guide scope in search of guide stars). Or you can press the "Auto find star" button and EAGLE CORE will select a star. The green square will move by selecting the guide star. Now press the "Calibration" button. EAGLE CORE will move the guide star to calculate how the mount behaves as a result of the corrections sent through the ST4 autoguide port. At the end of the procedure, the word "Calibration done" will appear and the source of the axes will be shifted centered on the guide star with AR and DEC orientation of the frame relative to the displayed image.

Then press the "Start guiding" button to start the autoguide (EAGLE CORE will send the mount correction to the mount through the guide camera). The "guiding" screen will now appear as in the image to the right, with a reduced view of the field of the guide camera, the indication of the AR and DEC error, the average guide quality, and the guide graph that allows us to keep track of the quality of the guide. You can stop the guide any time by clicking the "STOP guiding" button.



Our tips for a precise guide

1. Pay particular attention to mount polar alignment: if the polar alignment is not accurate, the autoguide won't automatically correct the tracking errors.
2. Do not select a too bright guide star: if you do not find other guide stars, reduce the exposition time or the gain of the guide camera.
3. Check for the weights balance of the telescope on the mount (read the manual of the mount to understand how to get a perfect balance).
4. If your guide graph shows unstable values with positive or negative peaks, reduce the guide speed in your mount hand-pad (usually reduce from 0,5x to 0,25x).

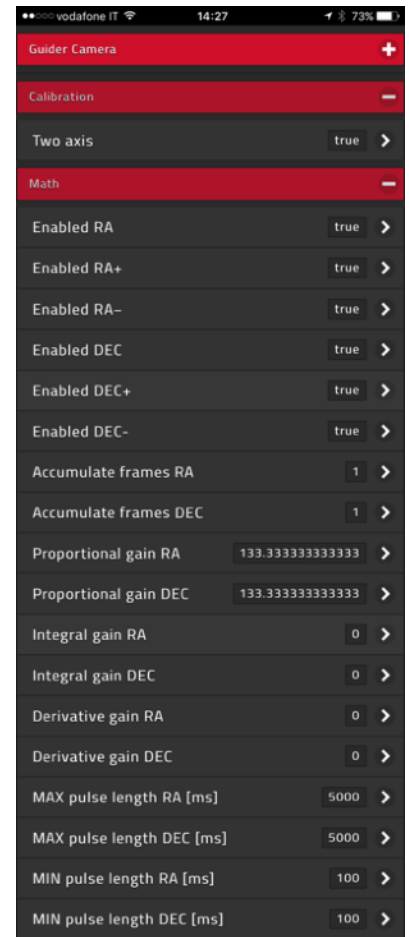
Step 6: advanced autoguide settings (optional)

If you want to adjust your guide system more accurately (for example, if you are using high focal length telescopes, it's advised to adjust the guide parameters to achieve better tracking accuracy). Click the Menu button and select Advanced Settings. In the "Calibration" submenu you find the "Two axis" parameter. By default it is set to "true" and then EAGLE CORE will perform the autoguide on both axes. If you use it a star tracker like the Star Adventurer that supports autoguide corrections only on the RA axis, select "false".

The "Math" box below shows the advanced parameters associated with the guide algorithm that uses a PID control.

All parameters can be defined separately for each axis (AR and DEC) and they are:

1. Enable RA/RA+/RA-/DEC/DEC+/DEC- - enable or disable axis corrections (enabled by default)
2. Accumulate frames RA e DEC - enables the average coordinate values by using N images, and corrects at the end of the medium value (set to 1 by default)
3. Proportional gain - the coefficient of the proportional term in the PID control.
4. Integral gain - the coefficient of the integrative term in the PID control (set to 0 by default)
5. Derivative gain - the coefficient of the derivative term in the PID control (set to 0 by default)
6. Maximum pulse - the maximum duration of the correction pulse (set to 5000ms by default).
7. Minimum pulse - the minimum duration of the correction pulse (set to 100ms by default).



What does PID mean?

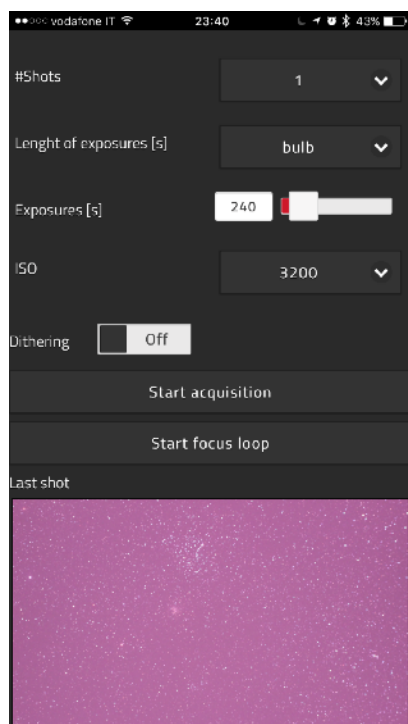
Whenever a device must maintain a constant value (in our case, the position of the guide star), it needs an algorithm that corrects the errors from the ideal position. PID means **P**roportional - **I**ntegrative - **D**erivative. First of all, it regulates the autoguide based on the *proportional* parameter, that is, with a correction proportional to the detected error (the greater the error, the greater the applied correction). However, if the correction is exceeded, the autoguide can become unstable as the telescope "swings" around the ideal position of the star. This is why the *integrative* value is added as the sum of all the errors in time and that, "remembering" the previous errors, minimize the pendulum that can be created with the proportional system (making the entire system less reactive and fast). To improve performance, we add the *derivative* parameter to calculate a forecast error: if the error is increasing, this parameter will give more force to the correction than the only proportional parameter. Reversely it will lead to a lower correction if the error is decreasing, sign that we are close to the ideal position of the guide star.

PID control coefficients adjustments should be made empirically, using the mounted telescope and observing how the guide quality changes according to the parameter set. The idea is to find coefficients that do not lead to too weak or too strong guidance. We recommend adjusting first of all the proportional value and, for example, changing by 10, anche check for the guide quality. If you notice a constant error in one direction, you can change the integrative value that takes into account the previous guide corrections. Defining the coefficients, consider that the values can be different for the 2 axes. If you performed a good polar alignment, DEC axis guide can be performed at a lower frequency, on average every 2 to 4 images. This prevents excessive movement along this axis and then removes unwanted movements.

'Maximum pulse' value is the duration of the maximum correction pulse and, in practice, it corresponds to the time between two captures of the guide camera. It is usually not necessary to change this value. The 'Minimum pulse' is more important as it defines the minimum duration of the correction. If the corrected correction is greater than or

equal to the 'Minimum pulse', it is sent to the mount otherwise it is discarded; then, if the 'Minimum pulse' value is too high, the mount will be guided with few corrections and the autoguide accuracy will be low. If the threshold is too low, the corrections will be too many with a consequent continuous correction around the ideal position of the star (and hence you will get a too strong guide).

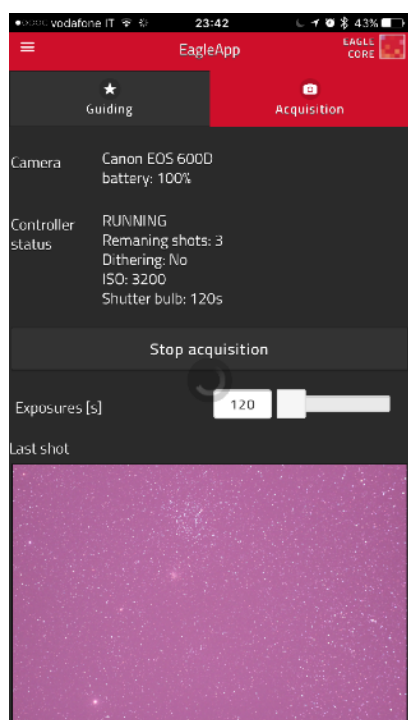
Step 7: record pictures with DSLR or mirrorless camera



Now that the mount is tracking the target object and the autoguide automatically corrects the tracking errors, you can record the image. Select the "Acquisition" tab, adjust camera settings and capture images. **For a correct use, DSLR camera has to be connected to one of the EAGLE CORE USB ports, set in Manual mode (or Bulb if your DSLR camera has this mode), used with a free memory card (we suggest to format the memory card before use with EAGLE CORE), without auto noise removal (auto dark), mirror lock up and automatic rotation of the image.**

In "#Shots" insert the number of images you want to capture. In "Length of exposures (s)" select the length of the exposures ranging from a few milliseconds to the "bulb". If "bulb" is set, in the "Exposures (s)" parameter you can enter the exposition time in seconds (up to several minutes). In order to change the shutter speed, you can quickly drag the lever or click on the field and enter the exposure time using the virtual keyboard of your device. In "ISO" you set the ISO sensitivity of the camera. Then press "Start acquisition" to start the image capture process. In this case, the camera is set automatically by EAGLE CORE to save the images in the camera's memory card in high quality RAW + JPEG mode.

The "Acquisition" tab will be as shown in the figure, showing the connected camera model, battery level, status of the acquisition procedure, the number of remaining images until the end of the acquisition, Dithering state, the ISO set on the camera, and the set time for each shot.



You can stop the capture process at any time by pressing "Stop acquisition". *Caution: The "Stop acquisition" button does not stop the capture process instantly, but wait for the end of the last exposure.* The last captured image is downloaded to EAGLE CORE and displayed in the box below. It is possible, during the focusing, to zoom in and check the star focus and the quality of the picture. *Caution: Last shot always displays the last captured image, you can not select or view other images in the camera memory.*

In order photograph bright objects such as the Moon or planets, it's not necessary to perform long expositions and the exposure times may also be lower than one second. Instead, when you want to photograph deep-sky objects such as nebulae, galaxies, or star clusters, consider that the exposition times required may be very long. You will notice that the subject will appear in the photo even after several minutes of expositions. To better record these weak objects, you can record a sequence of images: for example, in the "Acquisition" tab you set the #Shots field to a value greater than 1. Then EAGLE CORE will record many images of the same object, keeping the perfect tracking thanks to autoguide.

When we add many images of the same object, we increase the signal/noise ratio and thus improve the visibility of deep-sky objects. Look at this comparison of the single image of M31 shot with Canon EOS 7D, 200mm f/4 lens and EAGLE CORE: on the left the single 300 seconds image, on the right the sum of 6 images, 300 seconds each, for a total exposition time of 1800 seconds.



In the image you can better see the whole body of the galaxy and the image noise is also lower (since when we add more images, the noise which is random is mediated). Saved images will then be processed with a special astrophotography software. There are many softwares to do this but, for starters, we recommend the free DSS (find a guide on how to process the images at <https://www.primalucelab.com/astronomy/blog/deep-sky-stacker/> in our site).

If we have made a proper polar alignment of the mount and, in the case of capturing images with long exposition times, we started the autoguide, we will be reasonably certain that all images will be properly tracked for the duration of the capture sequence. We can begin to record images with EAGLE CORE!

Questions and answers

Q: if I disconnect my smartphone or tablet to WiFi, does EAGLE CORE stop working?

A: No, because EAGLE CORE is on the telescope and, when you launch the sequence acquisition, it's independent from the device you use to control the EAGLE CORE remotely.

Q: Where do I save my pictures?

A: Acquired images are saved directly to camera memory card. EAGLE CORE downloads the last captured image in jpg format and displays during the capture process.

D: can I install other software in EAGLE CORE?

R: No: EAGLE CORE has the EAGLE OS operating system, with drivers and software already installed to autoguide and capture images with DSLR and mirrorless cameras.

D: can I connect EAGLE CORE to the internet?

R: You can not use EAGLE CORE to access the Internet: EAGLE CORE creates a Wi-Fi network to be used for its control using external devices.





D: what devices can I use to remotely control EAGLE CORE?

R: You can use any smartphone, tablet (with iOS, Android or Windows Mobile) or computer (with Windows or OSX)

D: can I control EAGLE CORE from more devices at the same time?

R: Yes, you can access EAGLE CORE at the same time with up to 5 devices.

Recommended accessories for EAGLE CORE

 <p>PLUS Vixen+Losmandy dovetail clamp (PLLMORVLP)</p>	 <p>60mm CompactGuide guide scope (PLLCG60)</p>	 <p>QHYCCD QHY5L-II mono camera (QHY5L-II-M)</p>
 <p>PLUS 80mm guide rings (PLLANGU80P)</p>	 <p>AC adapter for Eagle - 5A (PL1000025)</p>	 <p>Eagle-compatible power cable for Canon EOS and Nikon DSLR camera</p>
 <p>SESTO SENSO robotic focusing motor (SESTOSENSO)</p>	 <p>PLUS 90mm Vixen dovetail bar (PLLVIX90P)</p>	 <p>PLUS 140mm Vixen dovetail bar (PLLVIX140P)</p>



Troubleshooting

Q: When I start autoguide calibration, guide star doesn't move and I get an error message.

A: An error message during calibration may be related to a not working ST4 autoguide cable. Please change it with a new ST4 autoguide cable and try again. If you still have this error, it can be related to high mount backlash or too small autoguide speed settings in your mount hand-pad. Please increase the guide speed settings your mount hand-pad and try again.

Q: When I start autoguide after calibration, the green square is still on the star, but the origin of the axes is not centered on the star.

A: If after the calibration, the guide star is not in the same point it was before calibration, this is because of mount backlash. After calibration is complete, EAGLE CORE moves the guide star to the original position. Please wait the star comes back to the original position before starting image acquisition.

Q: During acquisition I get this error "Dithering failed. Acquisition stopped".

A: This error may be related to high backlash of your mount. When the EAGLE CORE moves the image to make dithering, if your mount has too much backlash the image doesn't shift and the following image does not start. Please change the "Guiding Tolerance" value in "Advanced settings" (under Dithering): you have to try different values since this is based on the mount internal backlash.

Q: Guiding corrections in the graph are huge.

A: Please reduce the guide speed settings your mount hand-pad and try again.

Q: When shutting down the EAGLE CORE by using the off button in the EAGLE CORE app, the EAGLE CORE reboots.

A: This is normal behaviour of EAGLE CORE. The EAGLE CORE (differently than a Windows computer) can be turned off by simply removing power IN cable (and this is safe).

INFORMATION TO USERS



According to art. 26 of Decreto Legislativo 14 marzo 2014, n. 49 "Attuazione della Direttiva 2012/19/UE sui rifiuti di apparecchiature elettriche ed elettroniche", the symbol of the barrel placed on the equipment or its packaging indicates that the product at the end of its useful life must be collected separately from other waste.

The user will therefore have to give the end-of-life equipment to the appropriate separate collection centers for electronic and electrotechnical waste or to return it to the reseller upon the purchase of a new type of equivalent equipment, one by one.

Properly differentiated collection for the subsequent start of dismantled equipment for recycling, treatment and environmentally compatible disposal helps to avoid possible adverse effects on the environment and health and favors the reuse and / or recycling of the materials contained in the equipment.

The abusive disposal of the product by the user implies the application of the administrative sanctions as per D.Lgs. 152/2006.

Compliance with the RAEE legislation (D.Lgs. 49/2014)

PrimaLuceLab is registered to AEE Register with number IT17030000009790

PrimaLuceLab adheres to Sistema Collettivo ERP Italia for the compliance to RAEE legislation.



WARRANTY

- 1) The PrimaLuceLab product warranty is effective from the date of purchase and is valid only if it is with the invoice (or receipt) of purchase.
- 2) The warranty covers the product against defects in workmanship and includes the cost of the replaced material and labor.
- 3) The warranty does not cover any damage caused to the product or defects or failures that occur due to improper installation , improper use and/or deterioration due to normal wear.
- 4) THE GUARANTEE DOES NOT APPLY IN THE FOLLOWING CASES:
 - Repair by anyone not authorised by PrimaLuceLab .
 - Invasive interventions or tampering with internal and/or external parts.
 - Missing of the invoice (or receipt) of purchase.

TERMS OF SERVICE

Technical assistance is performed exclusively by PrimaLuceLab or its authorised resellers. All returns must be received with our permission (to be asked writing an email to support@primalucelab.com) . YOU HAVE TO add to the shipping the invoice (or receipt) of purchase and the detailed description of the defect. For products without the invoice (or receipt) of purchase, repair and shipping costs are always paid by the customer.