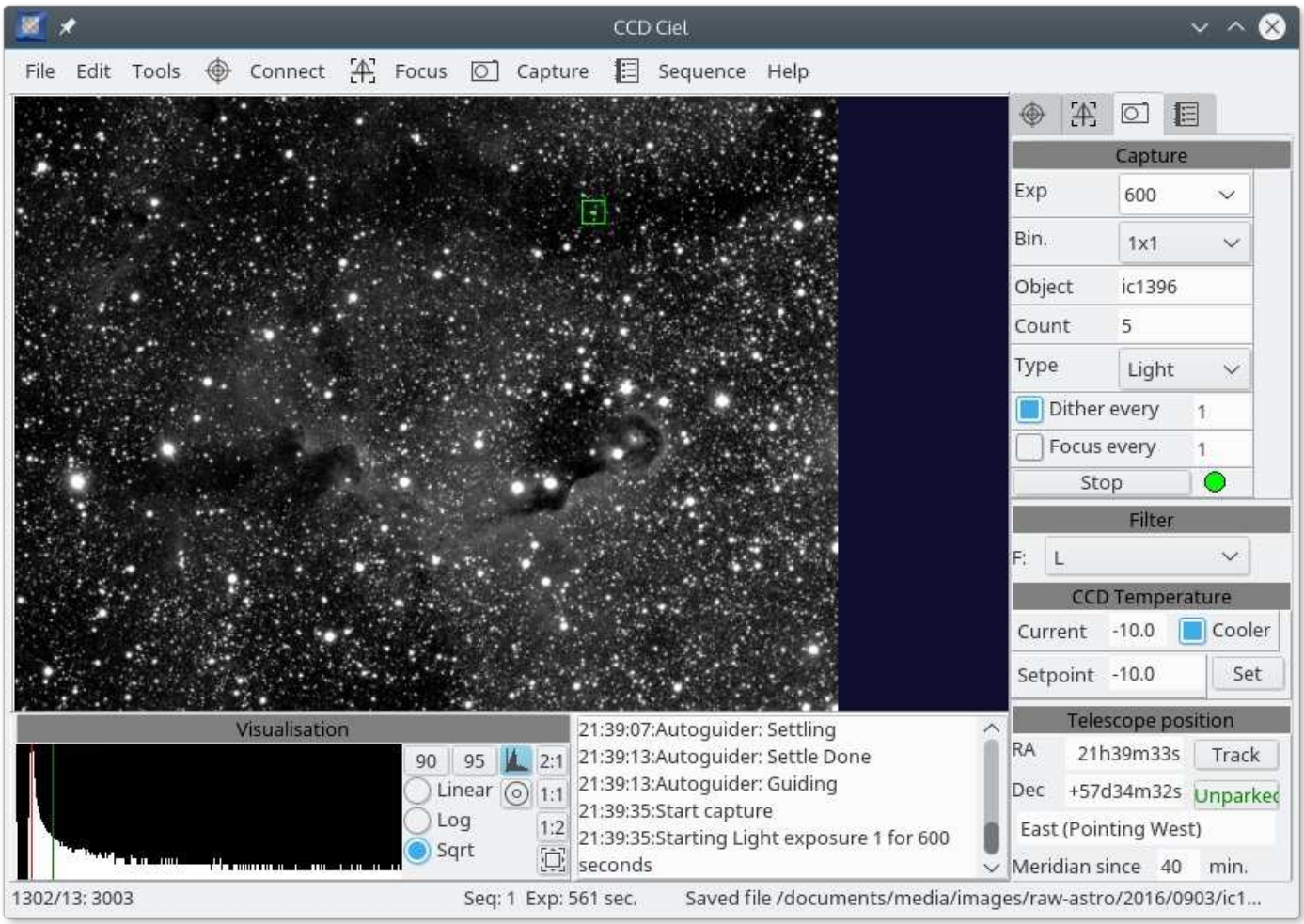
CCDciel

English documentation

Edited: November 18 2017

Last version is available from the wiki at
http://www.ap-i.net/ccdciel/en/documentation/start



Documentation

You can contribute to these pages [1].

Tutorial

- The program screen
- Connecting the equipment
- Global configuration
- Focusing
- Simple capture
- Automated sequence

Reference Manual

- Menu File
- Menu Edit
- Menu Tools and toolbox
- Menu Help
- Right click menu
- Status bar

Installation

- Installation on Ubuntu, Debian
- Installation on Linux
- Installation on Windows
- Installation on Mac OS X

Dependencies

- ASCOM
- INDI
- Astrometry.net
- Star Locator Elbrus
- PlateSolve 2

Credit

Tools

CCDciel make use of the following development tools:

- Free Pascal [https://www.freepascal.org/] compiler
- Lazarus [http://www.lazarus-ide.org] IDE and library
- BGRABitmap [http://wiki.freepascal.org/BGRABitmap] component
- Synapse [https://www.ararat.cz/synapse] library
- WCSTools [http://tdc-www.harvard.edu/wcstools/] library

Developer

- Patrick Chevalley
- Han Kleijn

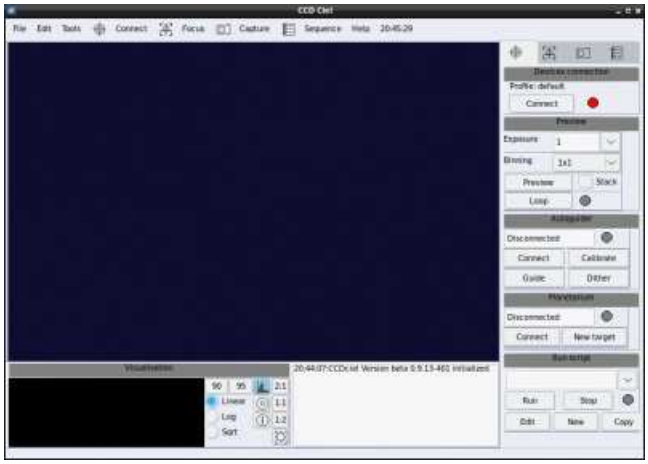
License

[1] Contribute by using the wiki at http://www.ap-i.net/ccdciel [http://www.ap-i.net/ccdciel]

Tutorial

1- The program screen

When you start the program you see the following screen:



On the top you have the standard menu: File, Edit, Tools, Help.
And represented with their icon the menu: Connect, Focus, Capture and Sequence. This menus are shortcut for the main tools functions available in the left part.

On the left is a tab control with this same four entries, they group the controls necessary for connecting the equipment, focusing the camera, take a capture or run a sequence of operation.

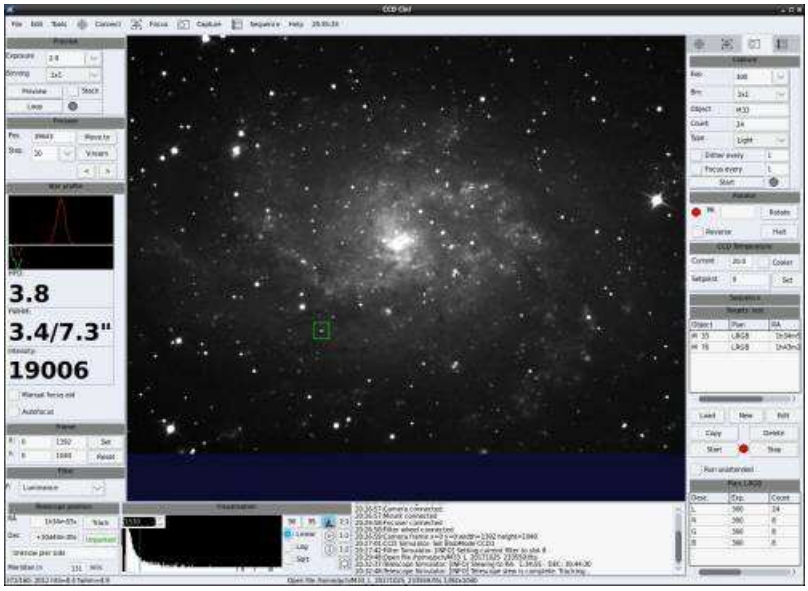
On the bottom is the visualisation control for the picture preview and a log with messages from the current operations.

Finally the remaining space in the center of the screen will be used to display the picture preview.

This default screen is designed to fit the small screen of an old laptop. But it can be customized if you can use a bigger screen or if you not use every tool.

Use the menu Tools to show or hide the tools you want. For example if you not use a motorized rotator you can uncheck the rotator entry to simplify the Capture tab.

You can drag and drop every tool to another part of the screen, just grab the title and move it on one of the screen border.



If you use a big enough screen you can make all the control visible at the same time without using the tabs.

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Tutorial

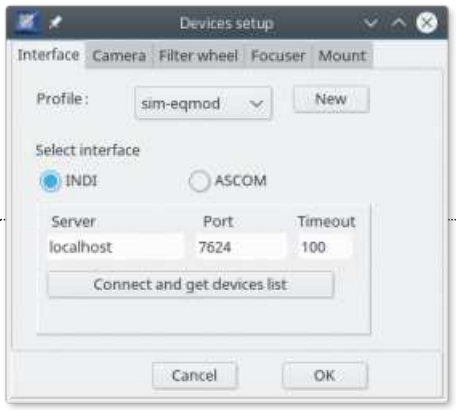
2- Connecting the equipment

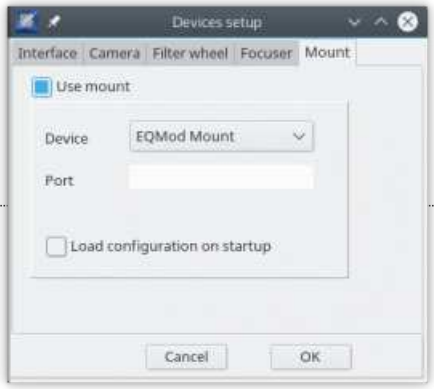
When you are a first time user, you have to select first the correct equipment drivers and set some settings.

First step is to select INDI interface (typical in Linux) or the ASCOM interface (typical MS-Windows) to communicate with your camera, mount and any other equipment.

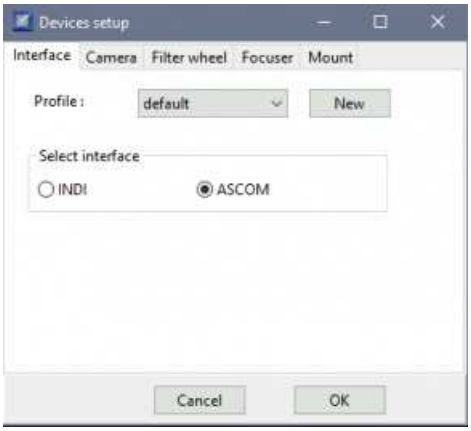
The program will automatically open the **File→devices setup** menu.

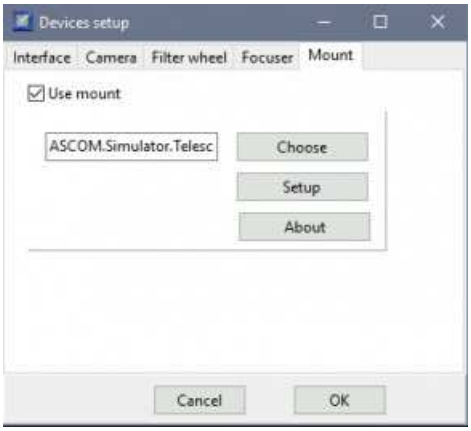
Select either INDI





or ASCOM interface.





Select also the mandatory camera driver and other equipment like mount or focuser but that can also be done later.

Click okay and program will create a new default profile for your equipment. All the devices and all the program options will be stored in this default profile. You could later create an additional profile with different settings, equipment or location.

Next menu will show the default options. The first thing to do is to set the capture folder to something like like in Linux to /home/username/capture which or for windows from the default C:\ to something like C:\CCDciel

When ready click the OK button.

Select the left tab (pointer icon) and locate the Connect button at the top. The red dot indicate you are not connected to any device. Below the connet button you will see the mandatory camera, mount if selected and any other equipment.

Click Connect, after a few seconds the light change to green with all the connected device listed below.

If something go wrong one or more device color can change to orange when the program is still trying to connect or red when an error is received. You can look at the messages box for any indication about the error. If you still have connect problems, yo could disable temporary the equipment driver in **File→devices setup** menu. Minimum equipment is the camera only.

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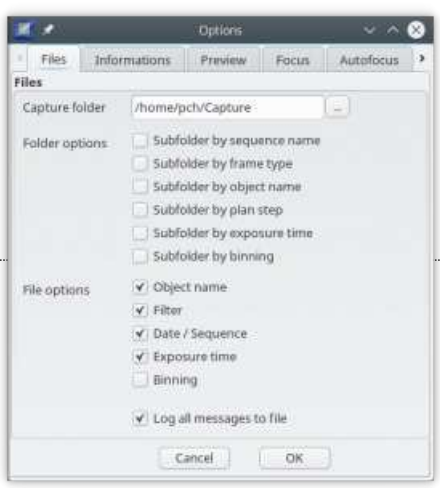
Tutorial

3- Global configuration

You access the global configuration from the menu **Edit→Preferences**.

There is a number of options for every part of the program and many can be examined later.



For now be sure to set a valid capture folder to save your images, and your observatory latitude and longitude that are used for different function in the program.

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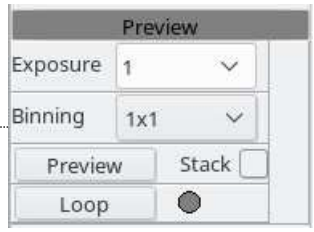
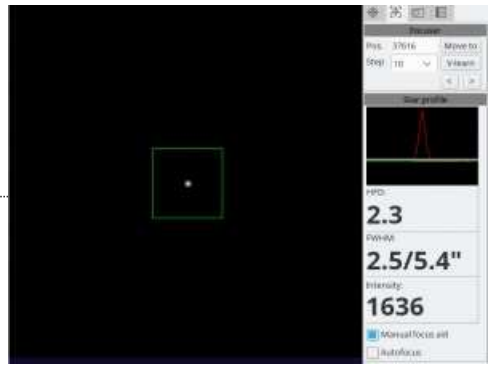
Tutorial

4- Focusing



Point your telescope at the sky and set the Preview exposure time and binning. Click on the Loop button.

Start with 10-15 seconds exposure time if you are way out of focus to see some large out of focus stars and move the focuser to reduce the size of the star disk. If you near the correct focus reduce the exposure time to 1 seconds less.



Let the preview in loop and click the Focus tab to show the focuser and star profile

Double click on a star, check it is not saturated, and check “Manual focus aid” to magnify the star image.

You can now use the focuser buttons, or manually turn the knob to make the star as small and bright as possible.

When ready uncheck “Manual focus aid”.

Leave the Auto-focusing disabled for later use. This requires more configuration.

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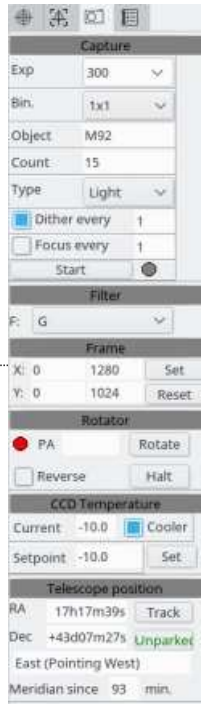
Tutorial

5- Simple capture



Open the Capture tab and set the required options:

- The exposure time
- The binning
- The name of the object
- The number of exposures to take
- Be sure the type is Light, other setting may let the shutter closed!

You can also choose to dither between exposures and to regularly adjust the auto-focus.

If you have a filter wheel you can specifiy the filter to use.

You can specify the frame dimensions if you don't want to use the full sensor surface.

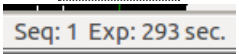
If you have a rotator the green/red light indicate if it is calibrated or not. Then you can set the rotation angle.

And if you can control the CCD temperature enter the desired value in Setpoint, and click the Set button.

When all settings are correct click on the START button to start capturing.

The telescope box will indicate the telescope position, the park and tracking status and the remaining time to reach the meridian.

The status bar shows the image number (count) in progress and the remaining exposure time



After each exposure is finished, the image is shown and the file is saved according the settings. A message in the status bar indicates the last saved file

it will continue for the number of exposures (=count) set.
After finishing you could change the filter and start the next series. Or automate it fully using a sequence.

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Tutorial

6- Automated sequence

Sequences allows you to fully automate the imaging. At the sequence tab you can specify all steps required for unattended operation.

The sequence example on the right will first image the objects M13 and M92 and finally park the telescope.

Attached to the M13 and M92 objects is the LRGB-4H plan specifying 24 images using a luminance filter (L), 8 images using a red filter (R) and finally 8 images using a blue filter (B). All images with an exposure of 300 seconds and the total duration of the plan is around 4 hours.

The last object in the list is a “Script“ with a plan specifying how to park the telescope.

Running this sequence should keep the equipment unattended busy for around 8 hours.

To take full advantage of this automation you need to configure:

- the astrometry resolver for plate solving and the slewing options
- the focuser and autofocus options and calibration
- the rotator connection and calibration.
- the autoguider connection and preferences
- the planetarium connection to help to set the object coordinates
- the automated meridian flip options

And most important you must be sure your telescope mount and all the equipment include a way to protect themselves against an unwanted operation. This include hardware slew and tracking limit on the mount.

You can read more on how to edit a sequence in the specific sequence page.

File Menu

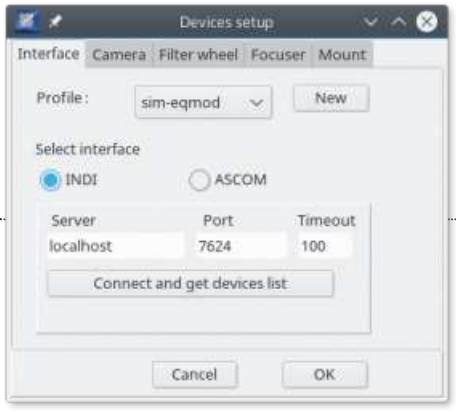
The **File** menu includes the following options:

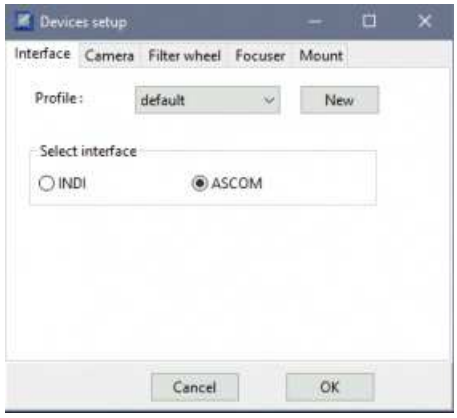
- Devices Setup
- Bad pixel map
- Open FITS file
- Save FITS file
- Open reference image
- Clear reference image
- Quit

Device setup

Open this window from the menu File → Device setup before to connect to any devices.

Interface





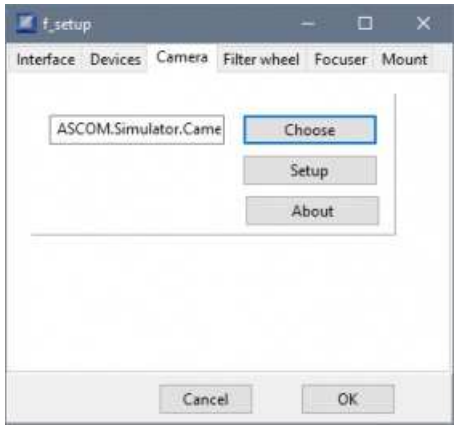
The first tab “Interface” let you select the kind of drivers you want to use, INDI or ASCOM if running on Windows.

Create a new profile for your equipment.
All the devices and all the program options will be stored in this profile, allowing to have completely different settings for your different equipments or locations.

For INDI you have to enter the network name or IP address, and the port of the INDI server, then click the button “Connect and get devices list” to make the program know which devices are available.

For ASCOM there is no additional information.
Note that the program will close and restart if you change between INDI and ASCOM.

Camera



Select the camera to use with CCDciel, from the dropdown list for INDI or using the ASCOM chooser.
A camera is mandatory so you cannot leave this page unconfigured.

For ASCOM you can click the Setup button to access the driver options now before the camera is connected.

For INDI the “sensor” field is to select the sensor to use for dual-chip camera, you probably always want “Main sensor” here.

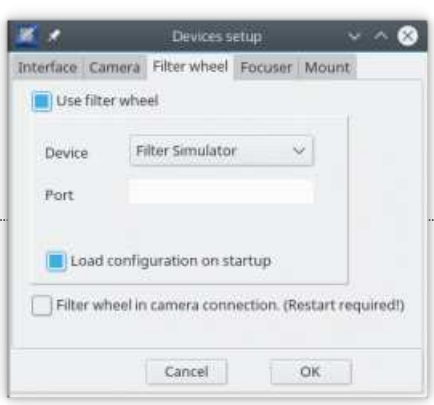
Check the corresponding box if you want to automatically load the INDI saved configuration when the device is connected.

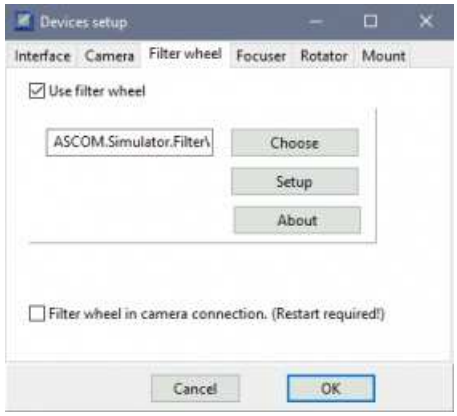
Then select how you want INDI to transfer the image data:

- **Network** the normal transfer mode you can use with local and remote INDI server.
- **RAM disk** may improve the performance if you use a local INDI server. Be sure the path you set point to an in memory disk, it's size need to be two time the size of one of your FITS image.

For INDI the driver options are available from the menu Edit/INDI settings.

Filter wheel



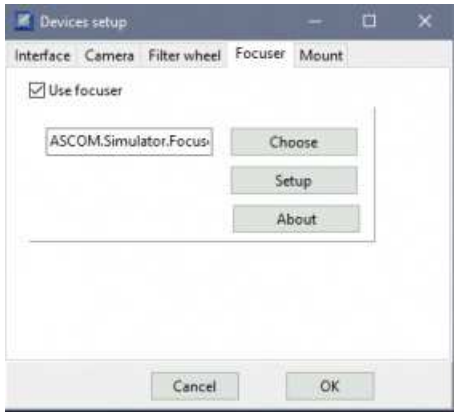


Check “Use filter wheel”.

Select the filter wheel to use with CCDciel, from the dropdown list for INDI or using the ASCOM chooser.

Or check the corresponding box if the filter wheel is commanded by the camera driver.

Focuser

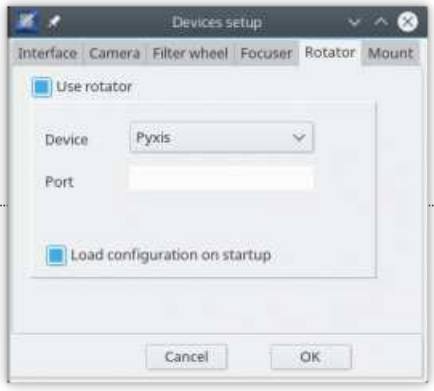


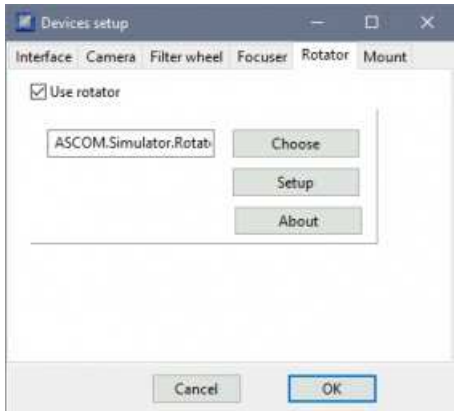
Check “Use focuser”.

Select the focuser to use with CCDciel, from the dropdown list for INDI or using the ASCOM chooser.

Or check the corresponding box if the focuser is commanded by the mount driver.

Rotator

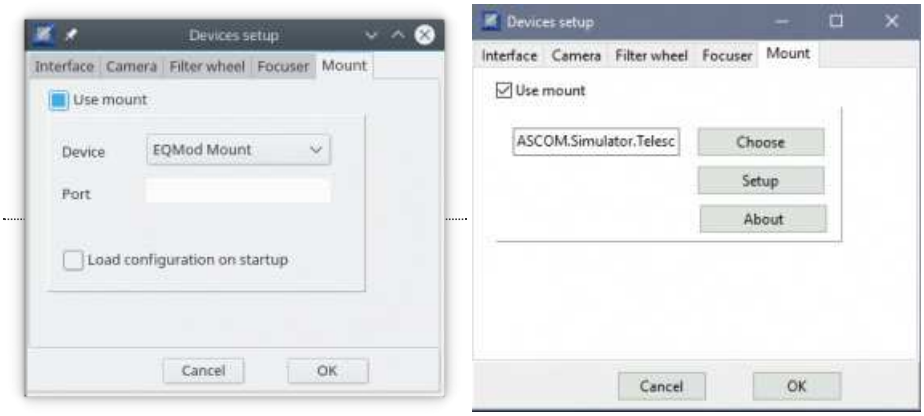




Check “Use rotator”.

Select the rotator to use with CCDciel, from the dropdown list for INDI or using the ASCOM chooser.

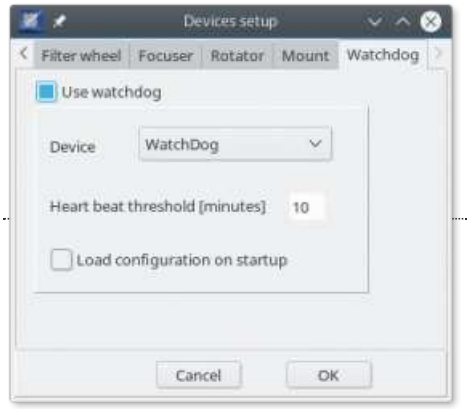
Mount



Check “Use mount”.

Select the telescope mount to use with CCDciel, from the dropdown list for INDI or using the ASCOM chooser.

Watchdog



Check “Use watchdog”, select the INDI driver and set the threshold value in minutes.

The watchdog [http://www.indilib.org/support/tutorials/154-securing-remote-observatories.html] is a specific INDI driver that can park the mount and the dome if the connection is lost with CCDciel for more than the threshold time limit. There is no similar function when using ASCOM drivers.

Click OK after you finish your setting.

Bad/Hot pixel map

The bad pixel map will prevent the auto-focus or slewing function locking on a hot pixel rather then on a star.

The bad pixel map will be only applied on preview images, focus or slewing images. It is not used for capture images. Those images are not altered.

Procedure:

1. Camera should be connected and cooling on if available.
2. Set the required binning in Preview tool. Us the same binning as for the focus and slewing
3. Select an exposure time between 10 and 60 seconds.
4. Cover the camera or telescope similar as taking a dark image. If your camera has a shutter it will remain closed during the exposure.
5. Select menu **File → Bad pixel map → Create bad pixel map**

6. Click Continue. A dark will be taken and number of hot pixels will be reported in the log window.

Take a preview image and check if the bright hot pixels are surpressed.

To remove/clear the bad pixel map select the menu **File → Bad pixel map → Clear bad pixel map**

Error: If you get an error message: “too many hot pixels”, increase the sigma threshold value in the menu **Edit → Preferences → preview** options. If successful the program log will report the number of hot pixels suppressed.

A typical threshold value is 5 for CCD and 8 for a modern CMOS sensors. Decrease the threshold value if you want suppress more hot pixels. Normally you should surpress maybe 5 to 30 hot pixels but you can go much higher.

Open FITS file

From the menu File → Open FITS file.

This let you load a FITS file in the preview window instead of taking the image with the camera.

This is useful if you want to review a previous shot from the capture sequence, or to play with some other image.

Note this is not a multi-purpose FITS file viewer. It is intended to display images from the camera but it could fail displaying FITS files from other programs.

Save FITS file

From the menu File → Save FITS file.

This let you save to a FITS file the image in the preview window.

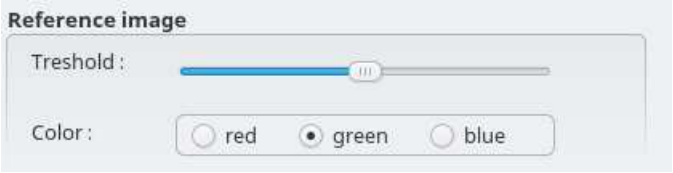
This is not used part of the capture sequence as the files are automatically saved, but this can be useful to save an image taken with the Preview function or loaded with File → Open FITS file.

Be careful this Preview image can be processed for bad pixel if you create a bad pixel map.

Reference image

You can load a reference image of the object you want to capture to adjust the position of the telescope and the rotation of the camera. This is very useful to continue a sequence over many night.

You can adjust the display threshold and the color of the reference image in the preview options.
Normally you want the threshold to display only the stars from the reference image.



To load the image use the menu **File / Open reference image**

Then start a preview loop, it show the new image over the reference.

You can now move the telescope or rotate the camera to match the reference.

When you are satisfied with the result you can remove the reference image from the menu **File / Clear reference image**

Tips:
To help to center the telescope open first the reference image with File / Open FITS file. Right click on the image and select “Resolve and slew to image center”. After the telescope stop slewing process as above to adjust the rotation.

Quit

From the menu File → Quit.

Exit the program and save the configuration.

If the devices are connected you are asked if you want to disconnect them.

Edit Menu

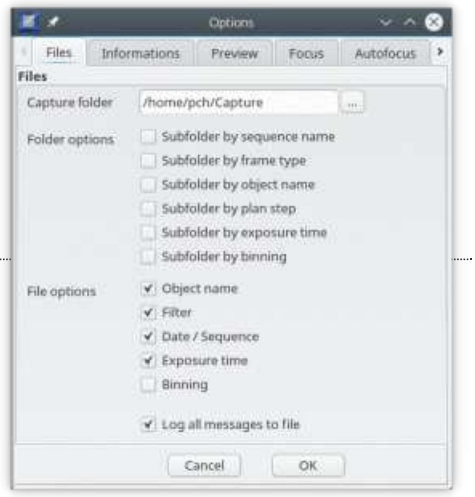
The **Edit** menu consists of the following items:

- Preferences
- INDI settings
- View FITS header

Preferences

From the menu Edit → Preferences. Set the global preferences and options for the program.

Files



With this menu you can specify how the image files are named and if they are stored in named folders. A typical imaging session will produce a great number of files so it is important to preserve the details for later processing.

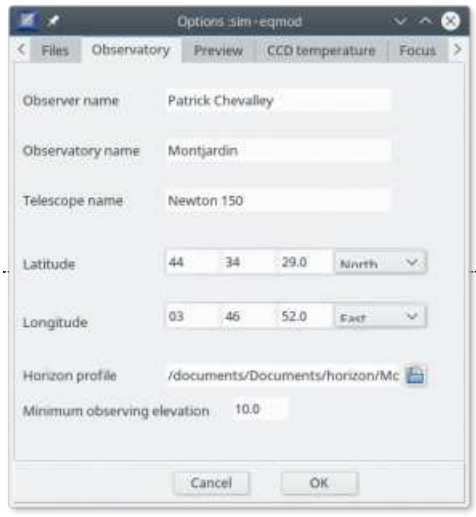
One way of working is to make subfolders based on object name and select for file names all details; object name, the filter, a date sequence, exposure time, binning. This is all depending on personal preferences and image processing software used later.

The base capture folder should be specified.

If Date/Sequence is checked the date and time is appended to the file name. If it is not checked a sequence number is appended to the file name.

The last checkbox is to save all log messages to a file for further inspection or debugging.

Observatory

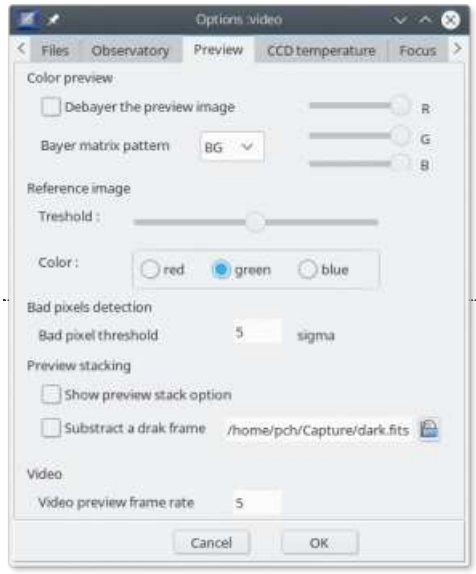


The informations on top will be set in each FITS file for the OBSERVER, ORIGIN and TELESCOP keyword.

The latitude and longitude of the observatory is used to get the Alt/Az position of the object, or for the scope_alignment script.

The “Horizon profile” and “Minimum observing elevation” are used to compute the object rise and set time in the sequence planner. If this values are set the rise/set time are relative to this limits.
You can set only one value or both. In the last case the highest elevation is used.
The horizon profile file is the same as the local horizon line in Skychart [https://www.ap-i.net/skychart/en/documentation/observatory#horizon].

Preview



This settings affect only the preview, the FITS files are recorded in RAW format to allow further preprocessing.

If you use a color camera you can **debayer** the preview image by checking the corresponding box and selecting the color pattern for your sensor. If you don't know what to select, make a test on a colorful subject on daytime. You can also do some color balance with the cursors on the right.

The **reference image** help you to frame a previous image, for example to continue a sequence.
Select the threshold and color for the display of the reference image.

The **bad pixel map** prevent the auto-focus function to lock on a hot pixel.
Select the threshold for detection of hot pixels for the bad pixel map.

Preview stacking allow you to stack the preview frames in real time. This feature is normally use for demonstration in public event.
You can select to disable this option to not risk an unwanted use during your imaging session.
Using a **dark frame subtraction** before the image addition improve the result quality.
This dark image must always be in 16bit format, even for a 8bit camera.

Select the preview rate for the **video**. Video require a suitable camera and is available only with INDI devices.

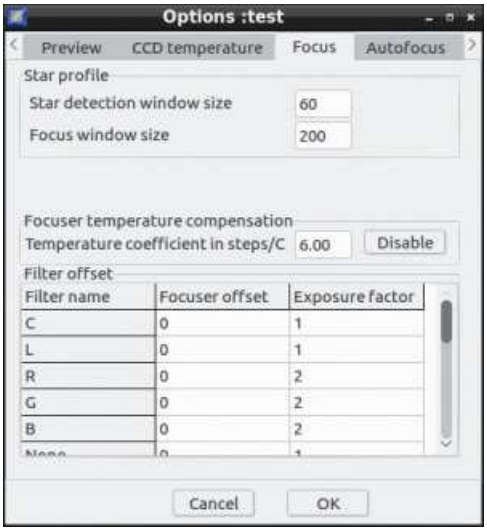
CCD temperature

Configure how you prefer to cool down and warm up you CCD sensor.

Consult your camera documentation to know if you need to limit the temperature change.
In this case check “Limit temperature change” and indicate the maximum rate in degree (Celsius) per minute.

Check the corresponding box if you want your camera to start cooling as soon it is connect to the program and indicate the target temperature you want.

Focus



Select the size in unbinned pixel of the star detection area and the size of the zoomed window for the focus mode. If you use a binning different than 1×1 for the focus operation the window size is reduced accordingly.

If your focuser can measure the temperature you can set here the temperature coefficient (in steps per Celsius) used to adjust the focuser position between the exposures, or to shift the auto-focus V curve accordingly. The coefficient is positive if the focuser needs to move UP in position when the temperature drop. The routine will adapt the focuser if the temperature difference is larger then 0.5 degrees.

Note that for a reflector telescope you typically have to turn the focuser OUT to correct for tube shrinkage. For a refractor you typically have to turn the focuser IN since the change in refraction coefficient is dominant and much larger then the tube shrinkage.

The temperature coefficient will help to reduce the number of autofocus actions required. It will work best when the temperature drops slowly and all parts of the telescope have time to adapt to the changing ambient temperature.

The compensation factor has to be measured empirical. Start with an almost zero factor=1 and monitor the autofocus focus position in the log as function of the reported temperature. If you sufficient data points which show a repeatable temperature coefficient enter the estimated factor in this menu. Some telescopes like a SCT could have less predictable coefficient and you most likely have to disable the coefficient and rely on the autofocus routine only.

If the factor is set well, the result of each autofocus routine run should be close to the previous focus position.

For each filter you can also set a focuser offset in focuser steps that will be applied to the focuser when you change the filter.

The filter exposure factor is used for the auto-focus functions. For example if your R filter require two time the exposure of the L filter set : L=1 R=2

Auto-Focus

Select the auto-focus method:

- **V curve:** This is the preferred method for an absolute position focuser. By measuring the size of a defocused star it can accurately calculate the ideal focus position. In advance your system has to be analyzed using the V-curve learning tool. This routine will measure the star size (HFD value) as function of the focuser position of your setup. The slope of the two lines left and right of the focus position is constant. Temperature changes, filters and slippage will only shift the focus but not the slope of the two lines. Once the V-curve (slope) has been measured accurately and saved using the V-curve learning tool, every auto focus operation will be done quick and efficient.
- **Dynamic:** This method can be used with relative position focuser. It require you start very near of the focus position and it make a small V curve every time.
- **Iterative:** A dumb method that move in one direction or another as long the star diameter is smaller. I as the advantage to work with any kind of focuser and you can start with a very defocused star. But it is slow and imprecise.
- **None:** If you want to use your focuser only manually.

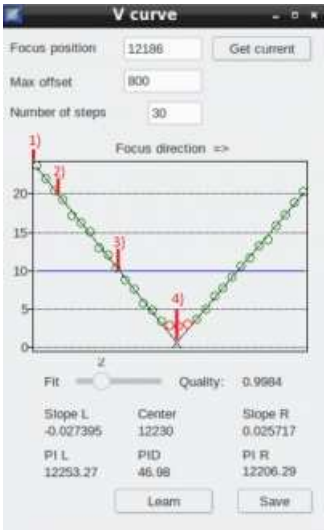
Common parameters

- **Exposure time** to use for the auto-focus operation. This time is multiplied by the filter exposure factor above.
- **Binning** to use for the auto-focus. Use binning 1×1 unless you are way oversampled.
- **The move direction** of the focuser. Depending on you setting the focuser can work better when moved in or out of focus.
- **Autofocus tolerance** is the maximum HFDthat can be considered as a successful focus. If the HFD after and auto focus operation is higher than this value the focuser position is set back to it's previous value.
- **The minimum SNR** of the star during the measurement. If a measurement SNR is higher than this value the auto focus operation is canceled and the focuser position is set back to it's previous value.
- **Autofocus star list**, select the magnitude of a star that give a good SNR for the auto-focus operation using the above exposure time. The telescope is moved to a nearby star of this magnitude to run the auto-focus. You can set here the precision require for the slew to put the star in half the image height. Use a lower precision than for target slewing to speedup the process.

V curve parameters

- **Near focus HFD:** We move the focuser to get this HFD to make the measurement on the V curve. This is **not** the focus HFD, it must be half way on the linear part of the curve. For example if your focus HFD is 3.0 and you make a V curve up to a HFD of 20.0, you can set 10.0 here.
- **n.exp :** The number of exposure we take to get a mean HFD value. Increase this value if the seeing is not good.
- **Start focus HFD:** The focus starting point on the V curve used to determine the Near focus position. Use a high value near the top of the V curve but inside the measurement area. A typical value is 20.0.
- **Slippage correction** If your focuser is prone to slippage you can activate a correction here. You must have configured the filter offset and the focuser temperature compensation, so we can be confident that the remaining offset is slippage.

The autofocus routine finds the focus in four focus movements using the slope information from the V-curve learning.



1. Move beyond the **Start focus HFD** to (1) taken into account any temperature drift. This to fix any mechanical hysteresis in your system.
2. Move to calculated **Start focus HFD** (2) taken into account any temperature drift. Here a number of exposures is taken and the average *new start HFD* is calculated.
3. Based on the average *new start HFD* of step 2) move using the slope factor to the calculated **Near focus HFD** position (3). This (3) will be already adapted to any focus drift and should be spot-on. Take a number of exposures and use the average *new near HFD* and slope factor to calculate the *new focus position*.
4. Move to the new calculated focus position (4).

- - If the SNR, signal to noise is too low, the routine is aborted.

- - Any focus drift will result in a drift of the *new start HFD* but not in the *new near HFD*.

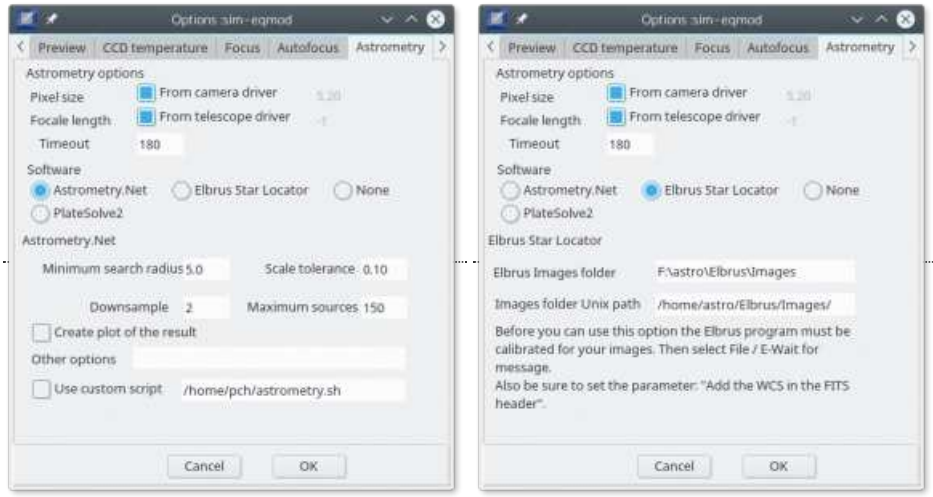
Dynamic parameters

- **Number of dynamic points:** The number of points we take on the curve. Do not set too high as this is done at every focus operation.
- **Movement between points:** The number of focuser steps we move between each measurement of the curve. The maximum focuser movement in and out of current position will be (Number of dynamic points)*(Movement between points)/2

Iterative parameters

- **Near focus HFD:** the HFD we start to use n.exp exposure to get a mean HFD. When the HFD is higher that this we take a single exposure to speed the process.
- **Initial movement** in focuser steps. This is the movement we use between measurement on the first iteration. It is then divided by two every time we change the direction.
- **Final movement** in focuser steps. When we reach this movement value we consider we are at the focus. This is typically the focus tolerance of your optical system.

Astrometry



Enter the camera pixel size and telescope focal length, or if applicable for your driver, check the box to get it automatically.

You can also adjust the timeout (in seconds) for a solve operation.

Select the software you want to use for the astrometry resolution of the images, you can use astrometry.net [http://astrometry.net/use.html] , Elbrus star locator [http://www.astrosurf.com/pulgar/elbrus/elbrusin.htm] or PlateSolve 2 [http://planewave.com/downloads/software/].

For each software you can adjust a few option to make them work quickly and reliably with your images.

Astrometry.net options

- Minimum search radius: Is a tolerance in degrees to the telescope position. Set this value high enough if you use the plate solving to make a pointing model.
- Scale tolerance: The tolerance on the pixel scale derived from the focal length and pixel size.
- Downsample: the image by this factor. Use at least 4 or 8 for DSLR images. For CCD it is better to use binning.
- Maximum number of source to consider.
- Create plot of the result: create png image with indication useful for debugging.
- Other options: any other option you want to give to the solve-field command.
- Use custom script: Use a script instead of the solve-field command. There is two example with the program, one for remote execution using ssh, the other for remote solving with the astrometry.net python script.
- On Windows only, you need to specify the Cygwin path to where astrometry.net is installed, for example C:\cygwin. See the installation instruction for more details.

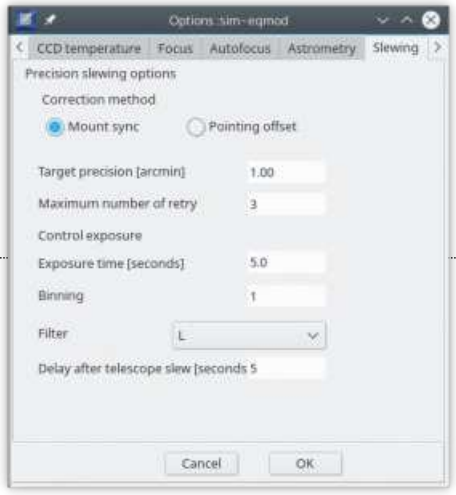
Elbrus options

- Elbrus images folder: the folder where Elbrus wait for new images to solve.
- Images folder Unix path: **Unix only**, the unix path corresponding to the previous one where CCDciel save the image for measurement.

PlateSolve 2 options

- Program folder: the folder you install the PlateSolve2 program.
- Wait after solve: the number of second the PlateSolve2 window remain visible after solving is complete.

Slew



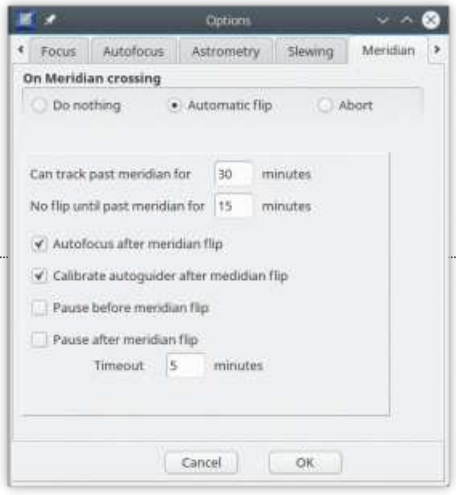
You can adjust how to correct the mount position after plate solving a control picture.
If your mount allow to sync anywhere select “Mount sync”, if not select “Pointing offset” to make the correction in software.
Use “Pointing offset” with EQMOD to not fool the pointing model.

Then set the precision you want/can reach and the maximum number of pointing/correction retry before to give up.

Set the parameters (exposure time, binning and filter) for the control exposure. This must give enough stars with your telescope/camera combination for the astrometry resolver to work.

If your mount need some time to stabilize after the movement you can increase the delay to wait before to take the plate solving picture.

Meridian



Configure here what you want to do when the mount reach the meridian.

- **Do nothing:** select this option if your mount is not affected by the meridian (fork mount).
- **Automatic flip:** automatically do a reversal of the mount to continue to track past meridian.
- **Abort:** abort the current capture and stop the mount.

Automatic flip options

- **Can track past meridian for:** the number of minute your mount can safely track past the meridian without flip. This depend on the declination, set the smaller value here.
- **No flip until past meridian for:** the minimum number of minute after the meridian we wait before to initiate the flip. This two parameters allow to loss the minimal time during a capture sequence, otherwise you can wait for a long as a single exposure time.
- **Autofocus after meridian flip:** In some case the focus point can move after a flip.
- **Calibrate autoguider after meridian flip:** If your mount do not report the side of pier to the autoguider you must check this option.

- **Pause before meridian flip:**
- **Pause after meridian flip:** this two checkbox give you a prompt before or after the flip to let you the time to do some manual operation on the mount (moving the counterweight for example).
- Timeout: The maximum time we wait for the after meridian pause, if you not close the prompt after this time the sequence continue automatically.

Autoguider

Select your autoguiding software, this can be PHD2 [https://openphdguiding.org/] or Lin_Guider [https://sourceforge.net/projects/linguider/].

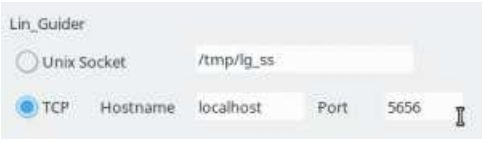
For **PHD2** you need to set the network name of the computer running PHD2 and the port number.

Set the options for dithering between the exposure, the number of pixel (in the guide camera) and if you want to dither only in RA (if you have a lot of DEC backlash).

The settle tolerance define how we consider the autoguiding as good after a dither operation or after it start.
It must stay within the number of pixel for Min.time. But we wait for the maximum of Timeout if this is not possible.
Set also the maximum time to wait if a new calibration is required.

In the case of guide star lost (passing clouds...) we can try to restart the guider after some time. This is useful if the star as moved out of the search area, but if the clouds are still there we can start guiding on a hot pixel. A value of zero disable this function.
Then we can abort the current sequence after some time, maybe the next object on the plan is in a clear area.

For **Lin_Guider** you can choose to communicate by a local Unix socket or by the TCP network, on Windows only the TCP option is available. The selection must correspond to the one in the Lin_Guider general setting.
The Star lost and Settle tolerance options are not used by Lin_Guider.



Planetarium

Select the planetarium application you want to use.

You can use the planetarium to select a target, or to display a solved image or image frame.

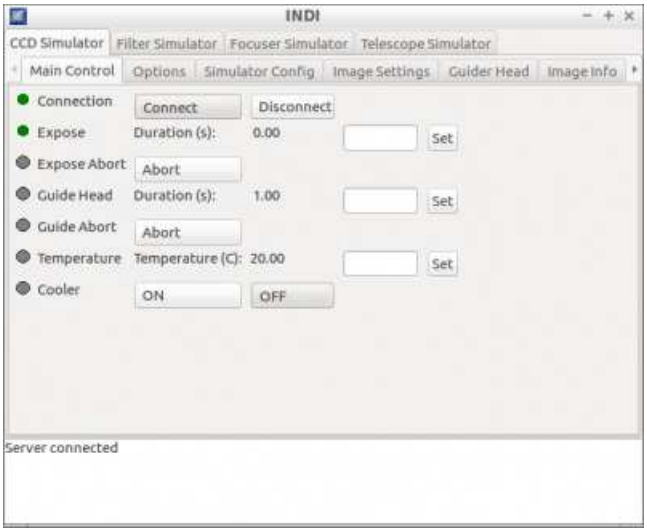
You have the choice between Skychart [http://www.ap-i.net/skychart]. HNSKY [http://www.hnsky.org/software.htm], or a SAMP [http://www.ivoa.net/samp/] application like Aladin [http://aladin.u-strasbg.fr/aladin.gml] or Topcat [http://www.star.bris.ac.uk/~mbt/topcat/].

INDI settings

From the menu Edit → INDI settings.

This menu is not active if you select the ASCOM devices interface.

This open a standard INDI client [http://www.indilib.org/] window where you can set any specific option for your devices.



View FITS header

From the menu Edit → View header.

Show the FITS header of the current file.

Tools Menu

The **Tools** menu let you select the tools you want to include or not in your screen.
Check or uncheck each tool to make it visible or not.
You can also move each tool on another part of the screen to suite your need just by dragging the tool title to one of the main window border.

It includes the following options:

- Connection
- Preview
- Autoguider
- Planetarium
- Script
- Focuser
- Star profile
- Capture
- Filters
- Frame
- Rotator
- CCD Temperature
- Telescope mount
- Sequence
- Video
- Visualisation
- Messages
- Clock
- Reset to default

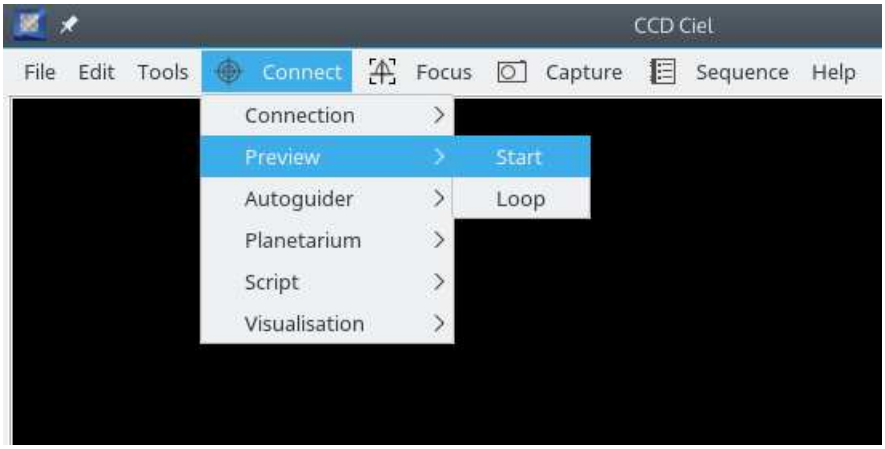
By default many tools are grouped in four tabs on the right of the window.

This correspond to the main functionality for a capture session.

- Connection and preview
- Focusing
- Simple capture
- Automated sequence

You can use the keyboard F1 to F4 to select one of the tabs.

This same function are also available from the main menu:

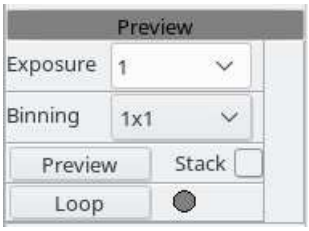


Connection Tool

This tool let you connect or disconnect your equipment and monitor the status.

It is a mandatory tool as the first thing to do after starting the program is to click the Connect button.

Preview Tool



This tool is to take a preview exposure for focusing or centering purpose.

Set the **exposure time** and the **binning** to use for the preview. This setting is totally independent of the Capture setting.

Click **Preview** for a single exposure or **Loop** to take exposure continuously until you stop it with the same button. The light change to green when the loop is active.

If you activate the “preview stacking” in the preferences you also see a **Stack** check-box.
When it is checked, every preview frame is added to the previous ones.
After you start the Loop, you see the object image to appear progressively in the screen as the number of frame increase. This function is often use in public demonstration.
You can use the menu File/ Save FITS file... to record the stacked image after you stop the Loop.

A new stack is started when you start the Loop, or after you take a preview without this option.

Autoguider Tool

This tool is to interface with the external autoguider.

Start the autoguider application and then click the Connect button.

It show the autoguider status and let you to start or stop autoguiding, force a new calibration, or dither.

This functions are used automatically by the sequence tool when the autoguider is connected.

Planetarium Tool

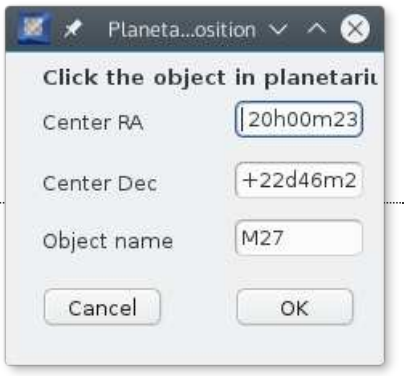
This tool is to control the connection to the planetarium.

It is used to display an astrometry resolved image with the right click menu, or to set the targets coordinates in the sequence preparation.

Click the **New target** button, click or search an object in the planetarium, then click OK.
This make a plate solved slew to the object position and set the object name in the Capture tool.
You must have a camera and mount connected before you can use this function.

The same box is used in the sequence editor to set the target coordinates.

Note that the target coordinates are apparent and could differ from the planetarium if the planetarium displays the position in equinox J2000 coordinates.



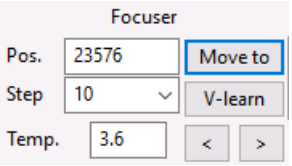
Script

This tool let you create or run a script

The scripts can be used to automate some task in CCDciel or to interface with external program for example to manage your observatory and equipment.

The same scripts can be used as a step in a sequence, or in specific conditions, but this box is a convenient way to create, test and quickly run any script.

Focuser Tool



With this tool you can control your motorized focuser manually and start the V-curve learning.

The tool will be adapted to an absolute or relative focuser.

The focuser temperature is reported if available.

V curve learning

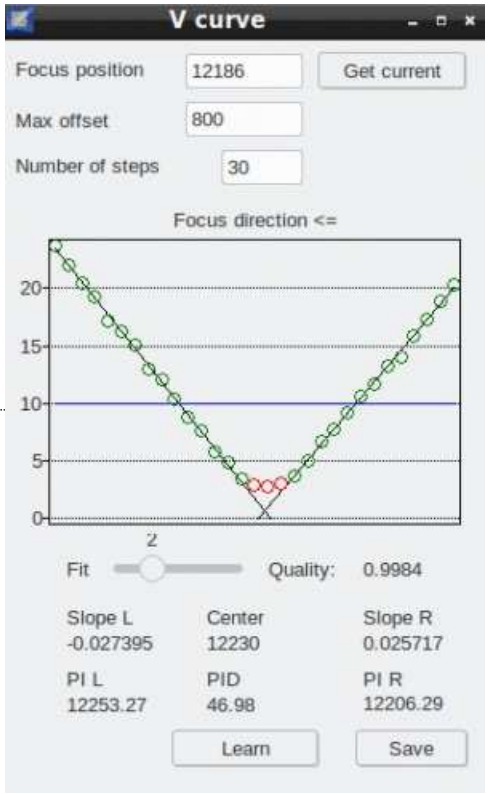
Introduction
In case you have an absolute position focuser and want to use V-curve auto-focus you have to run the V-curve learning routine first.

The routine steps the focuser and measures at several positions the size (HFD value) of a star. This will result in a typical V-curve of two lines left and right of the focus point, The slope of the lines will be used later in the autofocus routine for finding the focus. in this screenshot the routine will step from position 12186+800 to position 12186-800.

The focus position shown as 12186 should be approximately the best focus position. The maximum offset 800 as shown should be selected such that the HFD value at the beginning and end is above the **Start HFD focus**=20 so in this example 25.

Steps to follow
If you are using filters, select the luminance filter. Start an preview loop of about one second exposure and center on and select a bright star. Run the manual focus aid and check if the peak intensity indication is about 80% of saturation level using the star_profile tool. If not adapt the exposure accordingly or select an other star.

Be sure to stop the preview loop and press the **V-learn** button



The first time you launch this tool all the settings and graphic are empty.

Indicate the most accurate focus position you can estimate, as you make a manual focus just before you can click the **Get current** button here.

Set the Max offset value such that moving to the best focus position plus this offset give a defocused image with an HFD around 25.

Set the number of step to 30, this is a good value that allow for precision curve. But for the first try you can save

some time by setting it to 10. Just remember to repeat with 30 when you are accustomed with the procedure.

When this three numbers are set click the **Learn** button on the bottom.

This curve is slowly build up until the procedure is finished. Progress in is also reported in the Log and Star profile tools.

After the measurement are completed the curve should look as in the screen shot here. The graph shows the HFD value as function of the focuser position.

Check the following important points before you continue:

- The curve must be centered with top left and right about at the same level focus in the middle.
- It must extent to about the double of the value of Near focus HFD in the options, indicated by a blue line here.
- The two branches of the V must show a long linear part, specifically on the side of the base of the focus direction arrow (right on the screen shot).
- The branches must not flatten on the top. If you remark such behavior you must reduce the Max offset value.
- The move direction should be such that the learn routine moves the focuser in the same the direction as you have to adjust the focuser manually during the night when it is cooling down. If not change the direction in settings. For a reflector (mirrors) type of telescope you typically have to turn the focuser out if the temperature drops. For a refractor (lenses) type of telescope you typically have to turn the focuser in.

At the center of the V with the points marked in red.
It is important to exclude this points from the linear regression and you can use the **Fit** cursor to exclude more or less points.

When you adjust this cursor, look to maximize the Quality value on the right but also check the aspect of the black regression line across the green circles. The linearity must be specially good at the intersection with the blue line.

When you are satisfied by the result click the **Save** button. This will save the curve parameters and mean temperature for use in the auto-focus routine.

You can now try the Autofocus in the Star profile tool.

Star profile Tool

With this tool you can check the focus or start an autofocus run. It can be used with motorized focuser or manual focuser.

Make first a preview exposure and double click on a non saturated star.

The top curve is a cross-section of the star image. Try to make it as narrow as possible.

Below the previous relative HFD measurement in red and the intensity in green.

The HFD (Half Flux Diameter) unit is pixels.

The FWHM (Full Width at Half Maximum) units are pixels and arc-seconds.

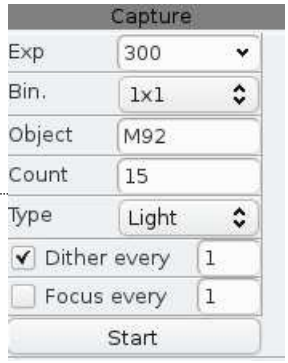
Optimum focus is reached when HFD and FWHM are at minimum.

The star peak intensity should be not be saturated.

Put a checkmark in front “Focus aid” to start a preview loop on the selected star area. See zoomed

Put a checkmark in front of the “Autofocus” to start the auto-focus procedure on the selected star. You must have configured the auto-focus in advance and have run then V curve learning tool and saved the result.

Capture Tool



This tool is to take a series of exposures.

Set the exposure time and binning required.

Enter an object name. The object name will be used for the file name and stored in the FITS header at keyword OBJECT.

Set the number of consecutive exposures to be taken.

Select the type of frame: Light for sky exposure. Bias, Dark, Flat for the calibration. This selection will be used for the folder name and stored in the FITS header at keyword IMAGETYP. If your camera has a shutter, it will be closed for Bias and Dark.

If dithering is required, put a checkmark and enter the image interval. Dithering requires the autoguider to be connected, configured and guiding from the Autoguider tool before you start capturing.

if autofocus is required, put a checkmark and enter the image interval. Autofocus must have been configured in auto-focus and V curve learning should have been run and result saved. For autofocus the telescope will automatically slew to a database star of configured magnitude. The slew to and return will only work accurately if you have configured the plate solver and slewing options.

Click the Start button to begin the exposure series. The same button can be used to interrupt the series.

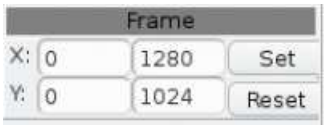
Filter Tool

With this tool you can control your filter wheel.

It will show the currently mounted filter.

To change the filter, select one from the list.

Frame Tool



This tool is to set the sensor area used for imaging.

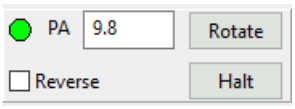
The first row is the horizontal starting point and width.
The second row is the vertical starting point and height.

You can set the values with the mouse on a preview exposure. Press the Shift key and the mouse left button to draw the frame.

Click the Set button to send the values to the camera.

Click the Reset button to reset to full frame.

Rotator Tool



With this tool you can control your motorized rotator.

To rotate to a new position type the new Position Angle and click **Rotate**.

Check **Reverse** if your optical configuration require to reverse the rotation to match the celestial position angle.

The light is red when the PA field is the rotator raw value without calibration.

Use the right click menu **Resolve and sync the rotator** to calibrate the rotation angle. After that the light is green and PA field indicate the celestial position angle.

The last calibration is restored when the rotator is connected.

CCD Temperature Tool

With this tool you can set the camera cooling setpoint and read the current imaging sensor[1] temperature.

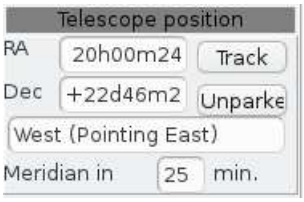
To start cooling, enter the temperature **Setpoint** (target) and click on the **Set** button. Automaticaly the **Cooler** check mark wil be checked.

To stop cooling un-check **Cooler**

If you have configured a maximum temperature rate the button text change to “Cancel” to let you cancel the current temperature change.

[1]) CCD or CMOS imaging sensor.

Telescope Tool



This tool display the current telescope RA/DEC position, the side of pier if reported by the driver, the time to or from the meridian.

You can park or unpark the mount using the corresponding button.
The Track button start the mount tracking.

Use the planetarium or the sequence tool if you want to move the telescope at a new location from CCDciel.

Sequence Tool

This tool is to control a complex sequence of exposure on one or more objects.

The top grid show the current list of targets.

You can Load an existing file with a list of target, create a New one, Edit the current list, Copy to a new list or Delete a list.

Use the Start and Stop button to start or interrupt a sequence.

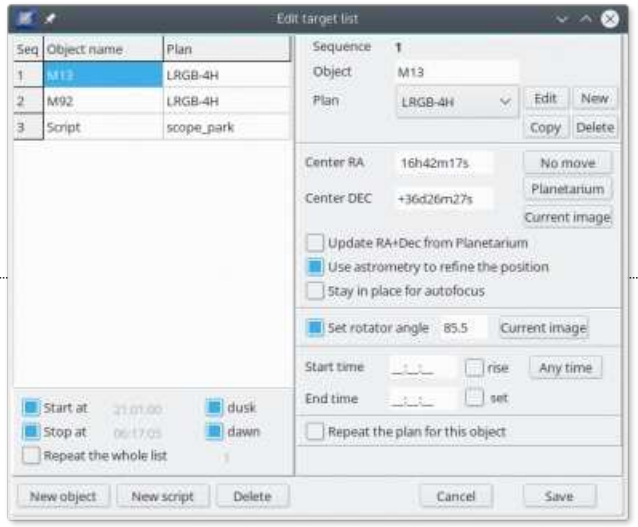
The “Run unattended” check box control how the program react in case of error.

- If is not checked a message prompt you on the screen what you want to do.
- If it is checked the operation is canceled.

The bottom grid show you the plan for the current target.

When the sequence is running the current target and step is highlighted.

Target editor



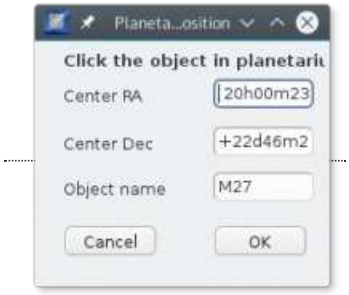
After you click New or Edit, the target editor let you modify the target list.

A target can be an object you want to take the images or a script to run in the sequence.

You can type the object name and coordinates in the corresponding box or click the Planetarium button to select the object in the connected planetarium application.
The coordinates can also be selected by plate solving the current image.
Or click the “No move” button to not change the telescope position.

Note that the target coordinates are apparent and could differ from the planetarium if the planetarium displays the

position in equinox J2000 coordinates.



Select the exposure plan to apply to this target using the dropdown box, or use the New button to create a new plan, or the Edit button to change the plan. You can also copy an existing plan or delete one.

If you are imaging a fast moving asteroid or comet you can check “Update RA+Dec” to ask the planetarium for the object coordinates just before the telescope is slewed to the target.
Be sure the planetarium is connected before to run the sequence.
Check the name of the object is compatible with the search function of the planetarium. No problem if you set the coordinate and name from the planetarium.
The planetarium must be set to follow the system time, otherwise the asteroid position is not updated.

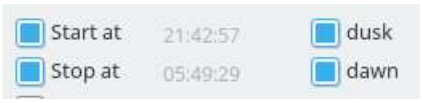
Check “Use astrometry…” box to refine the telescope position with an astromery solved control exposure. In this case you are ensured the selected object is framed exactly as required.

You can check “Stay in place for autofocus” if you are sure that the center of the image field contain a suitable star for auto-focus.
If unchecked or if the in place focus failed, the telescope is first moved to a focus star of the magnitude defined in the auto-focus preference, and returned to the target after the operation.

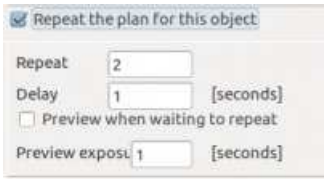
Check “Set rotator angle” to move the rotator at the specified angle.
You can type the position angle or use the current image orientation after plate solving.
Be sure the rotator is calibrated before to start the sequence if you use celestial PA.

You can set a time range for this target to be imaged, it will no be images before “Start time” or after “End time”. If “End time” is reach during exposure plan it is stopped and the next target is selected.
Click “rise” or “set” to automatically use the rise or set time of the object above the limits you define in the Observatory configuration, for the date of the observation.
To not use this function click the “Any time” button.

You can also define when the whole sequence start and stop.
Check the box “Start at” or “Stop at” and enter the time you want.
Check “dusk” or “dawn” to adjust the time for the astronomical twilight for the date of the observation.

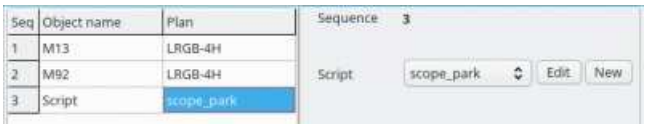


You can repeat the same target after a delay. Set the number of repetition and the delay. You can also start a preview loop while waiting for the next repetition.



You can also repeat the whole list a number of time by checking the box at the bottom of the list.

To add a script you just have to select the one you want from the list, or create a new script here.

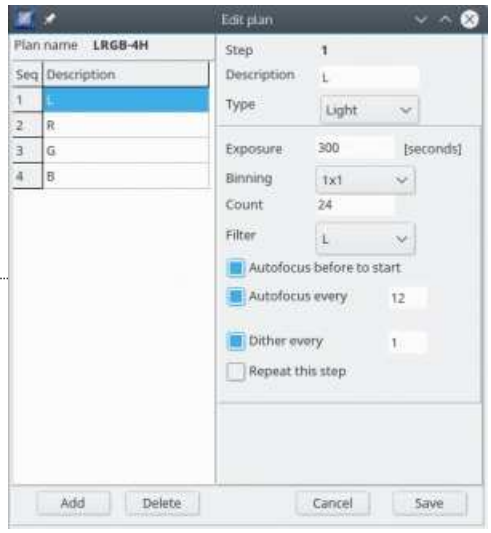


You can add a new target or script or delete one with the three buttons at the bottom of the list.

You can change the target order with a mouse drag/drop on the first column of the list.

The target list is saved when you click the Save button. If this is a new one you are asked for a file name.

Plan editor



Use the plan editor to specify the exposure steps to take of a target.

Give a description of the step that can be used to make a subfolder.

Set the type of frame, exposure time, binning, number of exposure, as in the Capture tool.

Set the filter to use as in the Filters tool.

Check corresponding box if you want to run an auto-focus at the start of this step.
For long steps you can also repeat the auto-focus after a given number of images.

You can repeat the same step after a delay. Set the number of repetition and the delay.

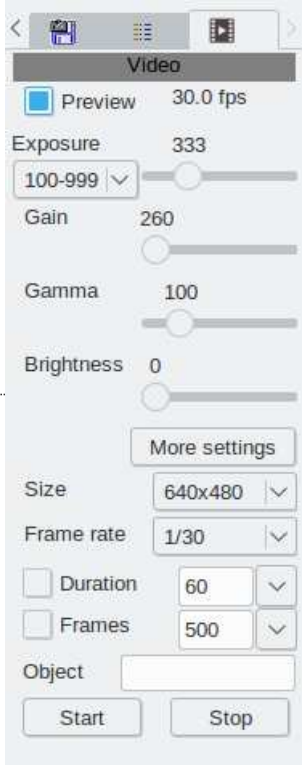
You can add a new step or delete one with the two button at the bottom of the list.

You can change the steps order with a mouse drag/drop on the first column of the list.

The plan is saved when you click the Save button.

Video tool

This tool is only available for INDI camera with video stream capability, specifically on Linux and Mac.
Because of the way INDI record the video, the file is written on the computer running the INDI server.



The video tool appear in a new tab after the Sequence if the INDI camera you connected as video stream capability.

You must first set the preview rate in the Preview options. Do not use a too high value as this preview frames have to transit by the network.

Check **Preview** to visualize the frames.

Select the exposure range in the drop down box then adjust with the cursor.

Depending on the camera there can be other settings for the Gain, Gamma or Brightness.

The **More settings** button open the INDI client for this camera, this let you to access some properties specific to your camera.

Two more drop down list are to select the image size and the frame rate.

Next are the video capture options, you can limit the capture time or the number of frames.

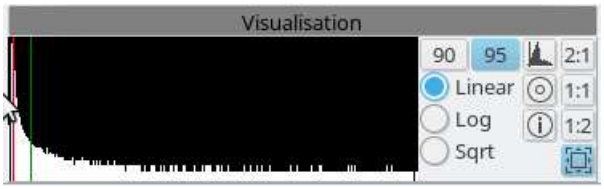
The object name is use for the filename the same way as the static images.

Click the **Start** to start recording. The recording to the video file is alway directly done by the INDI driver without any action from CCDciel.

Use the **Stop** button if you want the stop the recording before the planned end.

Visualisation Tool

This tool is to control the aspect of the preview image. None of the setting here have any influence to the image saved as a FITS file. They are only to help you to view the most of detail on the single raw images.

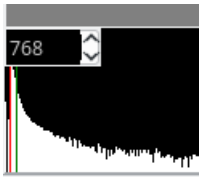


It is separated in two part, an histogram of the image and the control buttons.

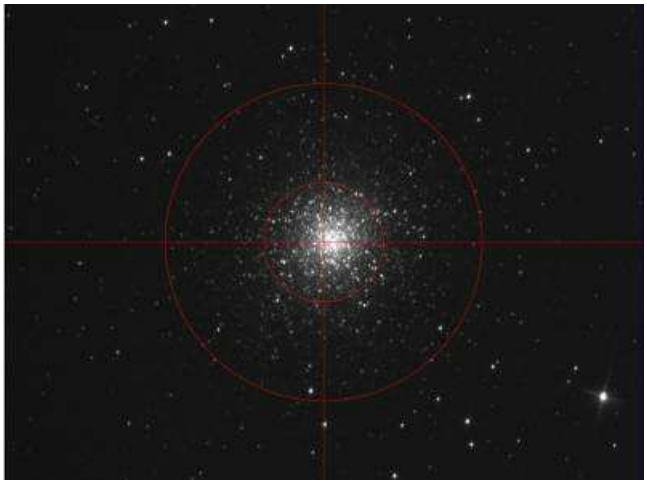
On the top row, the first three buttons are to control the range of histogram drawing, using 90%, 95% or the full histogram range. Reducing the histogram range help to see faint nebulae in the image.

The three left button let you select a linear, logarithmic or square root scale to display the image. Linear scale give the more contrast, but Log or Sqrt help to not saturate the brightest part of the image.

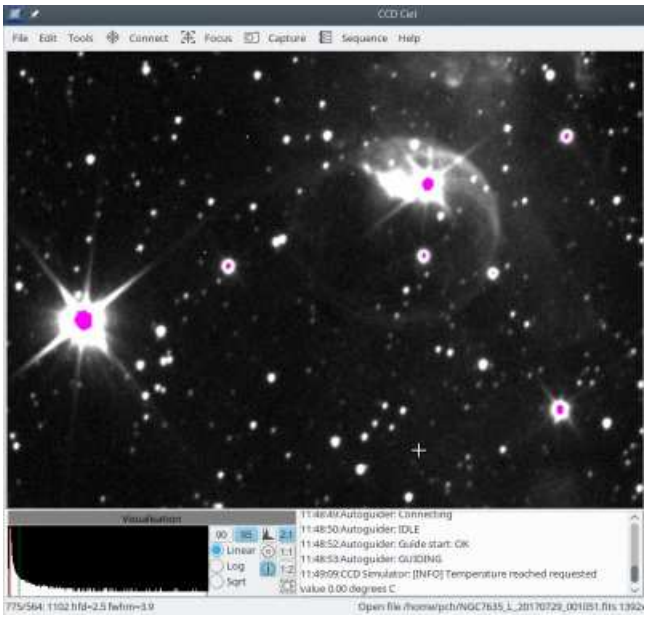
The four right button are preselected zoom level for the image.
You can also get other zoom level using the mouse wheel rotation
When the zoomed image is bigger than the screen you can move it with the left mouse button.



On the histogram you can move the high (green) and low (red) clipping bar with the mouse.
You can also directly edit the low and high threshold by moving the mouse cursor to the top left or right to display the edit box.



The bull eye button show the mark on the image. If the image is plate solved it also display an arrow with the North and East direction and print the image rotation angle.



The (i) button let you check for saturation in the image.

The overflow in the highlight area is marked in pink.
The clipped shadows area is marked in yellow.

Logging

This text window will report all messages (Log) from the program and drivers.

If configured, the messages (log) will be also stored in a text log file for further study. It essential to use this option if you let the program run unattended.

The file location is:

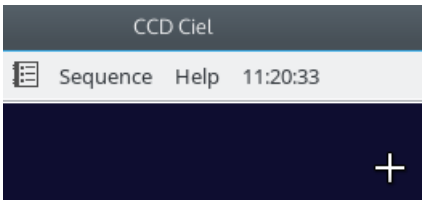
Linux:
/home/[your user name]/.config/ccdciel/Log

Windows:
C:\Users\[your user name]\AppData\Local\ccdciel\log

Note that above folders are typically hidden.

Clock

This tool show the current local time in the menu bar.



This is useful if you not have another clock on the computer screen but you may want to disable it if you use some remote desktop display on a slow network.

Help

Some help to use the software.

- **PDF documentation** open the PDF documentation installed with the software
- **Online documentation** open the documentation in a web browser
- **Report a problem** open the CCDciel bug tracker
- **Download latest version** open the SourceForge download page. Ignore this entry if you use a package from your Linux distribution.
- **About** show the program version and copyright notice.

Right click menu

Right click on the preview image to show the following menu:

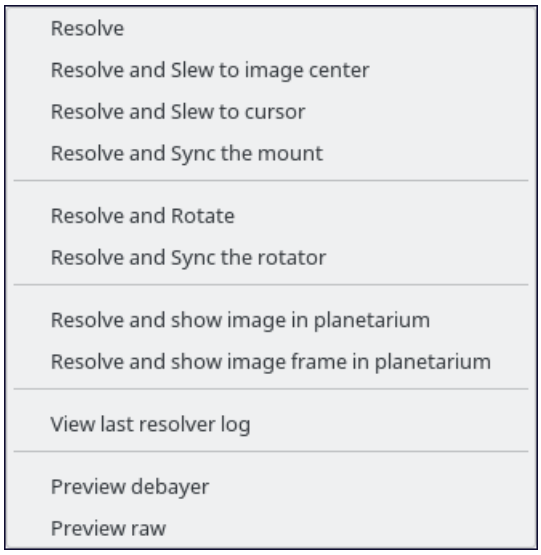


Plate solving functions

The image will be resolved (plate solved) and if successfull, the image position, pizel size and orientation will be saved in the FITS file. A second resolve request will use the saved solution. Once the image is resolved the astronomical position of the mouse cursor wil be displayed at the left bottom status bar in apparent coordinates.

Resolve

Resolve the image using the astrometry software and load the solved image in the preview.

You can show the RA/DEC of the cursor by moving the cursor on the image.
If you save the FITS file now it will include the astrometry solution.

Resolve and Slew to image center

Resolve the image using the astrometry software and if the resolution is successful move the telescope at the position of the image center.

This useful to center the telescope on an image taken on a previous session.

Resolve and Slew to cursor

Resolve the image using the astrometry software and if the resolution is successful move the telescope at the cursor position.

Can be useful to refine an object position but be careful of the mount backlash.

Resolve and Sync the mount

Resolve the image using the astrometry software and if the resolution is successful Sync the telescope at the current position.

If you use Eqmod for your telescope driver, this can be used to set the alignment points.

Resolve and Rotate

Resolve the image using the astrometry software and if the resolution is successful set the rotator angle to match the image orientation. The rotator must be calibrated before this function can work reliably.

Resolve and Sync the rotator

Resolve the image using the astrometry software and if the resolution is successful calibrate the rotator angle to match the celestial position angle.

Resolve and show image in planetarium

Resolve the image using the astrometry software and if the resolution is successful view the image in the planetarium.

Resolve and show image frame in planetarium

Resolve the image using the astrometry software and if the resolution is successful center the planetarium at the position and draw a frame of the CCD field.

View last resolver log

You can take a look at the output log of the astrometry resolver to help to solve a problem or to refine the performance.

Preview functions

The default display mode for bayer matrix color images is set in the preview preference. You can switch between the two mode with this menu.

Preview debayer

Debayer and display the color image if the current image is a raw color image with bayer matrix.

Preview raw

Display the raw image in black/white.

CCDciel Script

The scripts can be executed from the script tool or part of a sequence.

There is also standard script that are executed on defined occasion:

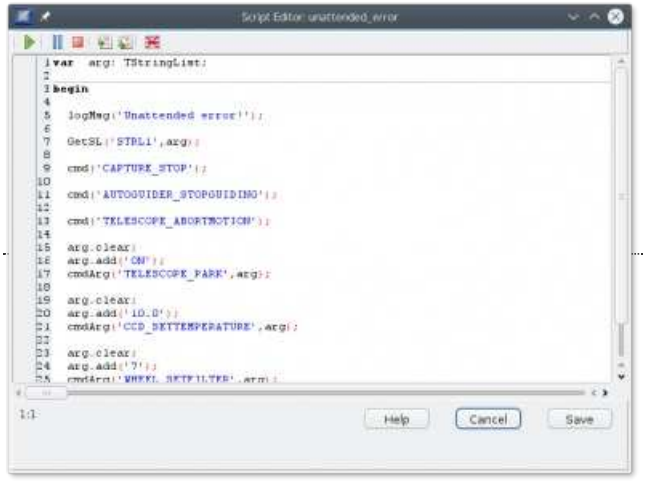
- **startup** is executed when the program in launched, even before any device is connected. This is the place you can automatically connect the devices, the autoguider and the planetarium.
- **shutdown** is executed when the program is closed.
- **end-sequence** is executed when a sequence is terminated normally. This is the place you can warmup the ccd and park the telescope. This script is not executed if you click the Stop button in the sequence tool.
- **unattended_error** is executed when a sequence is aborted, you can do the same as in end_sequence and add more cleanup. This script is not executed if you click the Stop button in the sequence tool.

The script language is very powerful and allow for complex tasks.
But this can also be as simple as sending a list of command to different devices.

There is limitations if you use an ARM processor for example with a Raspberry PI device. In this case some function are not working, specifically the command that require a TStringList.

Script editor

The editor allow to write a script .



The language to use is Pascal Script [http://en.wikipedia.org/wiki/Pascal_Script], based on Object Pascal [http://en.wikipedia.org/wiki/Object_Pascal].
Define first the global variables, then the procedure and function if any, then the private variable, and finally the main code start with **begin** and end with **end.**
Read the script example page for a quick start.

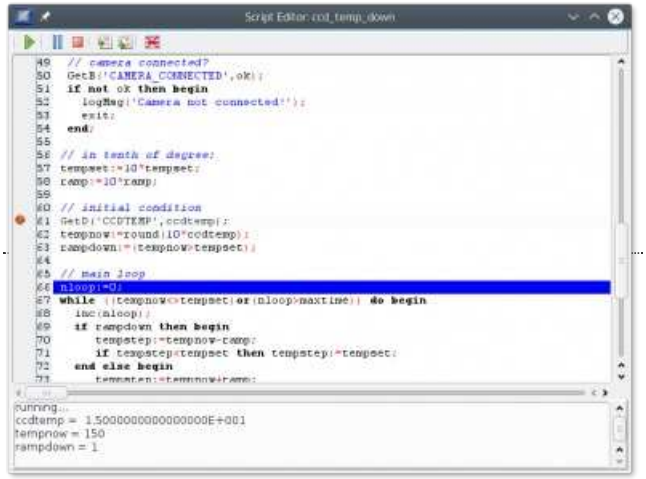
The functions specific to the interface with CCDciel are described in a separate script reference page.

Use the **Save** button to record your change and return to the main window.

The top button are related to the debugging function as describe below.

Script debugger

Simple debugging function are available to test your code.



To run the script in debug mode press the green arrow **Run** button. The program is first compiled.

In case of compilation error, the corresponding row is highlighted in yellow, and the error message is show in the bottom message area.

If the compilation finish without error the program start to run and stop on the first code line of the main procedure. The current execution position is highlighted in blue.

You can now use the **Step over** button to execute your program line by line.
The **Step into** button do the same, except if the current line is a call to one of your function. In this case **Step into** allow to run the function line by line, but **Step over** execute the function and stop at the main program next line.

You can also set a breakpoint on a specific line to jump directly at this position.

To set a breakpoint click on the leftmost column to show a red icon.
Use the Run button to jump to the next breakpoint. The current line is then highlighted in red.

You can remove a breakpoint by clicking on the red icon or all at at time with the **Remove all breakpoint** button.

You can display the value of variables when the program is in pause at a breakpoint or after a **Step over** click.
Just click on the variable name anywhere in the program source to display the value in the message area.
Note this work only for local variables, not for object properties.

You can use the **Pause** button to pause the program execution. This can be useful to examine the condition of an infinite loop for example.

The **Stop** button terminate the program execution immediately.

Script example

This page give tips and example of scripting functions.
You can also look at the template code provided with the program.
For more details about a specific function see the script reference page.

Generality

We first look in detail at the code of the scope_unpark script you can use to unpark the telescope. To open this script locate the script tool, select “scope_unpark” in the dropdown list and click the Edit button.
This cover many programming basis.

The full script code look as following:

```
{
  This script unpark the telescope mount
}

var ok,parked: boolean;
    arg: TStringList;
    r: string;
begin

  // telescope connected?
  GetB('TELESCOPE_CONNECTED',ok);
  if not ok then begin
    logMsg('Telescope not connected!');
    exit;
  end;

  // get park status
  GetB('TELESCOPE_PARKED',parked);

  if parked then begin
    getSl('STRL1',arg);
    arg.clear;
    arg.add('OFF');
    r:=cmdArg('TELESCOPE_PARK',arg);
    if r<>msgOK then logMsg('Telescope park: '+r);
  end
  else begin
    logMsg('Telescope already unparked');
  end;
end.
```

Take a look at each part in detail:

```
{
  This script unpark the telescope mount
}
```

Is a comment, you can use // {..} (*..*) to enclose your comments.

```
var ok,parked: boolean;
    arg: TStringList;
    r: string;
```

Define the variable we use later in the script.
Important variable type are: integer, double, string, boolean.
The Tstringlist type is use here to send a command argument to CCDciel.

```
  begin
```

The start of our script.

```
GetB('TELESCOPE_CONNECTED',ok);
```

We ask CCDciel about the status of a boolean variable to know if the telescope is connected, the result is in our variable ok.

```
  if not ok then begin
    logMsg('Telescope not connected!');
    exit;
  end;
```

We test the result of the previous command, ok is true if the telescope is connected, so we add the negation “not” to test for “not connected”. If the result of the test “not connected” is true we execute the code block starting at “begin” up to the corresponding “end”, this write a message in the log and exit the script.

```
GetB('TELESCOPE_PARKED',parked);
```

We continue and we do the same to check if the telescope is parked, with the result in our parked variable..

```
    if parked then begin
```

We test if the telescope is parked, in this case we can unpark.

```
GetSL('STRL1',arg);
arg.clear;
```

Request a TStringList object identified by STRL1. We clear any data that may stay in the object. We need this TStringlist to pass argument to a CCDciel command.

```
    arg.add('OFF');
    r:=cmdArg('TELESCOPE_PARK',arg);
```

Add the argument 'OFF' for the command and execute 'TELESCOPE_PARK' 'OFF'. This effectively unpark the telescope and the result is in variable r.

```
if r<>msgOK then logMsg('Telescope park: '+r);
```

We test the result is different than msgOK, in this case we write a message to the log to show the error from the driver.

```
 end.
```

The end of the script.

Open a document

The following code open an html page in the default web browser.
You can use any document type with this function, the document open with the default application the same way as if you double click the document in the file explorer.

```
begin
  OpenFile('document.html');
end.
```

Run a command

There is three different way to run an external command or program, depending if you want to wait for a result or the command completion or not.

No wait

If the command can run for an undetermined time or do not produce an output you need to use the following form. This example run the Skychart program and exit immediately without waiting you exit Skychart.

```
begin
  Run('skychart');
end.
```

Wait until the end of the command

If you need to wait the end of a command but it only produce an exit code to signal success or failure you can use the following form.

```
begin
  if runWait('/bin/bash -c open_dome.sh') then
    logmsg('Dome opened')
  else
    logmsg('Fail to open the dome')
end.
```

Wait for a result

The following command run the DIR command in the current directory. The result is stored in a stringlist and the first entry is show in the log.

```
var r:TstringList;
begin
  GetSL('STRL1',r);
  r.clear;
  RunOutput('dir',r);
  logmsg(r[0]);
end.
```

Script reference

This page contain reference material for scripting functions.

See the script description page for general information.

See the script example page for a quick start with the programming functions.

Script language

The language to use is Pascal Script [http://en.wikipedia.org/wiki/Pascal_Script].
For a complete reference of the Object Pascal language your can read the Free Pascal Reference guide [http://www.freepascal.org/docs-html/ref/ref.html]. But beware that some feature are not implemented by the script language, for example: no pointer, no assembler, no overloading.

In addition to the standard Pascal Script feature the following CCDciel specific function are added.

Constants

name	**value**
deg2rad	degree to radian conversion constant
rad2deg	radian to degree conversion constant
msgOK	returned when a CCDciel command complete successfully
msgFailed	returned when a CCDciel command fail

Global variables access

function GetS(varname:string; var str: string):Boolean;	
Get the global string variable identified by varname	
varname	**value**
LASTERROR	The text of the last error
Str1 .. Str10	Ten global variable for your use

function SetS(varname:string; str: string):Boolean;	
Set the global string variable identified by varname for later use	
varname	**value**
Str1 .. Str10	Ten global variable for your use

function GetSL(varname:string; var strl: Tstringlist):Boolean;	
Get the global stringlist variable identified by varname	
varname	**value**
Strl1 .. Strl10	Ten global variable for your use

function SetSL(varname:string; stlr: Tstringlist):Boolean;	
Set the global stringlist variable identified by varname for later use	
varname	**value**
Strl1 .. Strl10	Ten global variable for your use

function GetI(varname:string; var i: Integer):Boolean;
Get the global integer variable identified by varname

varname	value
Int1 .. Int10	Ten global variable for your use

function SetI(varname:string; i: Integer):Boolean;	
Set the global integer variable identified by varname for later use	
varname	**value**
Int1 .. Int10	Ten global variable for your use

function GetD(varname:string; var x: double):boolean;	
Get the global double variable identified by varname	
varname	**value**
TelescopeRA	The telescope position right ascension
TelescopeDE	The telescope position declination
TimeNow	The current time in TDateTime format
CCDTEMP	The current CCD temperature
Double1 .. Double10	Ten global variable for your use

function SetD(varname:string; x: Double):Boolean;	
Set the global double variable identified by varname for later use	
varname	**value**
Double1 .. Double10	Ten global variable for your use

function GetB(varname:string; var x: boolean):boolean;	
Get the global boolean variable identified by varname	
varname	**value**
TELESCOPE_CONNECTED	True if the telescope is connected
TELESCOPE_PARKED	True if the telescope is parked
TELESCOPE_EQMOD	True if the telescope use the EqMod driver
AUTOGUIDER_CONNECTED	True if the auto-guider is connected
AUTOGUIDER_RUNNING	True if the auto-guider is running
AUTOGUIDER_GUIDING	True if the auto-guider is guiding
WHEEL_CONNECTED	True if the filter wheel is connected
FOCUSER_CONNECTED	True if the focuser is connected
CAMERA_CONNECTED	True if the camera is connected
PLANETARIUM_CONNECTED	True if the planetarium is connected
PREVIEW_RUNNING	True if the preview is running
PREVIEW_LOOP	True if the preview is in loop
CAPTURE_RUNNING	True if a capture is running

Commands

function Cmd(cname:string):string;
Execute a simple command cname in CCDciel.

Valid Cmd() command are:

Command	Description

TELESCOPE_ABORTMOTION	Stop any telescope movement
TELESCOPE_TRACK	Start telescope tracking
EQMOD_CLEARPOINTS	Clear EqMod alignment data
EQMOD_CLEARSYNCDELTA	Clear Eqmod sync delta
EQMOD_STDSYNC	Set Eqmod in Standard sync mode
EQMOD_APPENDSYNC	Set Eqmod in Add point on sync mode
AUTOGUIDER_CONNECT	Connect to the autoguider software
AUTOGUIDER_CALIBRATE	Force a new calibration of the autoguider
AUTOGUIDER_STARTGUIDING	Start to guide
AUTOGUIDER_STOPGUIDING	Stop guiding
AUTOGUIDER_PAUSE	Pause guiding
AUTOGUIDER_UNPAUSE	Restart after pause
AUTOGUIDER_DITHER	Dither now
AUTOGUIDER_SHUTDOWN	Close the autoguider program
WHEEL_GETFILTER	Get the current filter number in the wheel
PREVIEW_SINGLE	Start a single preview
PREVIEW_LOOP	Start a preview loop
PREVIEW_WAITLOOP	Wait until the user stop the preview loop
PREVIEW_STOP	Stop any in progress preview or preview loop
CAPTURE_START	Start a capture
CAPTURE_STOP	Stop a capture
ASTROMETRY_SOLVE	Plate solve the current image
ASTROMETRY_SYNC	Plate solve the current image and sync the telescope
ASTROMETRY_SLEW_IMAGE_CENTER	Plate solve the current image and slew the telescope
PLANETARIUM_CONNECT	Connect the planetarium software
PLANETARIUM_SHOWIMAGE	Plate solve the current image and show in planetarium
PLANETARIUM_SHUTDOWN	Close the planetarium software
PROGRAM_SHUTDOWN	Close CCDciel
CLEAR_REFERENCE_IMAGE	Remove the reference image
AUTOFOCUS	Run auto-focus at the current position
AUTOMATICAUTOFOCUS	Move to a bright star and run auto-focus, return to last position when finished

function CmdArg(cname:string; arg:Tstringlist):string;
Execute a command cname in CCDciel with parameters arg. Add each parameter to the string list.

Valid CmdArg() command are:

Command	**Arguments**	**Description**
DEVICES_CONNECTION	ON/OFF	Connect or disconnect the devices
TELESCOPE_SLEW	RA, DEC	Slew to specified coordinates
TELESCOPE_SYNC	RA, DEC	Sync to specified coordinates
TELESCOPE_PARK	ON/OFF	Park or unpark the telescope
WHEEL_SETFILTER	number	Set the filter number in the wheel
WHEEL_GETFILTERSNAME	arg	On return arg contain the name of the filters
WHEEL_SETFILTERSNAME	arg	Put each filter name in arg
CCD_SETTEMPERATURE	temp	Set the CCD temperature
PREVIEW_SETEXPOSURE	exp	Set the preview exposure time
PREVIEW_SETBINNING	bin	Set the preview binning

CAPTURE_SETEXPOSURE	exp	Set the capture exposure
CAPTURE_SETBINNING	bin	Set the capture binning
CAPTURE_SETOBJECTNAME	name	Set the capture object name
CAPTURE_SETCOUNT	count	Set the capture image count
CAPTURE_SETFRAMETYPE	Light/Bias/Dark/Flat	Set the capture frame type
CAPTURE_SETDITHER	count	Set the capture Dither count
SEQUENCE_START	sequence	Load and start the sequence
SAVE_FITS_FILE	filename	Save the FITS file
OPEN_FITS_FILE	filename	Open the FITS file
OPEN_REFERENCE_IMAGE	filename	Load a reference image

Delay functions

procedure Wait(wt:integer);
Wait wt seconds before to continue the execution

function WaitTill(hour:string; showdialog: boolean):boolean;
Wait until the time is “hour”, encoded as 23:30:00 . If the time is already passed by less than 12h the function return immediately, if it is passed for more than 12h it wait for the next day. If showdialog is true a dialog with time countdown is show, this dialog also allow to cancel or to continue immediately, it return False if the wait is canceled.

Coordinates conversion

Procedure Eq2Hz(var ra,de : double ; var a,h : double);
Convert Equatorial ra,de to Alt/Az a,h for the location and time of the current chart, all angle in radian

Procedure Hz2Eq(var a,h : double; var ra,de : double);
Convert Alt/Az a,h to equatorial ra,de for the location and time of the current chart, all angle in radian

Formating and conversion

Function ARtoStr(var ar: Double) : string;
Return a string formated Right Ascension of ar value

Function DEtoStr(var de: Double) : string;
Return a string formated Declination of de value

Function StrtoAR(str:string; var ar: Double) : boolean;
Convert a formated string to Right Ascension decimal value

Function StrtoDE(str:string; var de: Double) : boolean;
Convert a formated string to Declination decimal value

Function JDtoStr(var jd: Double) : string;

Format a julian date to YYYY-MM-DD string

Function StrtoJD(dt:string; var jdt: Double) : boolean;
Convert a formated string YYYY-MM-DD to julian date value

Function FormatFloat(Const Format : String; var Value : double) : String;
Format a decimal number according to the Format [http://www.freepascal.org/docs-html/rtl/sysutils/formatfloat.html] specification

Function Format(Const Fmt : String; const Args : Array of const) : String;
The Format [http://www.freepascal.org/docs-html/rtl/sysutils/format.html] Pascal function

Procedure StrtoFloatD(str:string; var defval: Double; var val: Double);
Convert a string to a floating point value. Return defval if the string is a invalid number

function IsNumber(str: String): boolean;
Return True if the string represent a valid number

function StringReplace(str,s1,s2: String): string;
Replace all occurrence of s1 by s2 in str

Dialog

function MsgBox(const aMsg: string):boolean;
A message confirmation dialog. Return True if YES is clicked.

Procedure ShowMessage(const aMsg: string);
Display a message.

Procedure LogMsg(const aMsg: string);
Write a message to the log

Run external program

function Run(cmdline:string):boolean;
Execute the specified command. Return immediately without waiting for the execution to end.

function RunWait(cmdline:string):boolean;
Execute the specified command. Wait for termination.

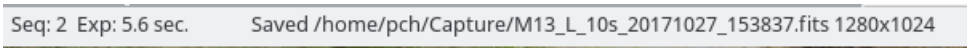
function RunOutput(cmdline:string; var output:TStringlist):boolean;
Execute the specified command, wait for termination and put the stdout to “output”. **Beware** this function can

completely lock the main program if it not finish in time.

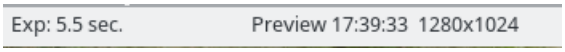
function OpenFile(fn:string):boolean;
Open a document file using the default program

The status bar

The status bar at the bottom of the program window show a number of information.

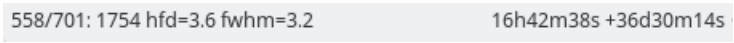


When a capture is running the status bar show the sequence number and the remaining time of the current exposure. On the right it show the name of the last saved image and the size of this image.



When a preview is running it show the remaining time of the current exposure, the time of the currently displayed preview and the size of the image

---



The left part of the status bar show information for the image at the mouse cursor position:
- The X/Y image coordinate of the cursor.
- The pixel intensity.
- The HFD and FWHM of the star under the cursor
- If the image is plate solved it also show the Right ascension and Declination of the cursor position, using the apparent coordinates if the telescope mount use the coordinates of the date, or J2000 if the telescope use this system. It show the apparent coordinates if no telescope is connected.

Installation on Ubuntu, Debian

Bellow installation procedure uses only command line approach, because this is the simpler way to follow instructions just by copy-pasting the commands in terminal.

This same procedure can be used with any system using deb packages (Debian, Mint, Raspbian, ...)

CCDciel and it's dependency are available from the same repository as Skychart [https://www.ap-i.net/skychart], but you need the unstable repository as long this program is in beta version only.

1. Add Skychart unstable repository:

   ```
   sudo apt-add-repository 'deb http://www.ap-i.net/apt unstable main'
   ```

2. Install the public key:

   ```
   apt-key adv --keyserver keyserver.ubuntu.com --recv-keys AA716FC2
   ```

3. Update repository:

   ```
   sudo apt-get update
   ```

4. Install CCDciel:

   ```
   sudo apt-get install ccdciel
   ```

See also the list of the optional dependencies to install to take full advantage of the software.

Installation on Linux

If your Linux system use deb packages,see Installation on Ubuntu.

For other Linux system you can download rpm or tar packages from the Sourceforge download [http://sourceforge.net/projects/ccdciel/files/] link.

The requirement are Gtk2 and libpasastro [https://sourceforge.net/projects/libpasastro/].

See also the list of dependencies to install to take full advantage of the software.

You can also compile the source code [https://sourceforge.net/p/ccdciel/code/] using Lazarus [http://www.lazarus-ide.org/index.php].

Installation on Windows

CCDciel can run on any version of Windows from XP to 10.

To use the devices connected to your Windows computer you need the ASCOM platform [http://ascom-standards.org/] and the drivers for you hardware.

But you can also use the devices connected to a remote Linux system (Raspberry PI for example) using the INDI protocol.

You can download the setup installer from the Sourceforge download [http://sourceforge.net/projects/ccdciel/files/] link.

See also the list of the optional dependencies to install to take full advantage of the software.

Installation on Mac OS X

CCDciel can run on a recent version of Mac OS X on a computer with an Intel processor.

To use the devices connected to your Mac computer you need the INDI [http://www.indilib.org/] library and the drivers for you hardware, available from CloudMakers [http://www.cloudmakers.eu/xindi/].

You can download the dmg installer from the Sourceforge download [http://sourceforge.net/projects/ccdciel/files/] link.

See also the list of the optional dependencies to install to take full advantage of the software.

ASCOM

ASCOM [http://ascom-standards.org] Platform is the standard astronomical equipment driver for Windows.

Install the ASCOM platform and the drivers you need from http://ascom-standards.org/Downloads/Index.htm [http://ascom-standards.org/Downloads/Index.htm] or from your equipment manufacturer.

INDI

INDI [http://www.indilib.org/] Library is the standard astronomical equipment [http://www.indilib.org/devices/] driver for Linux and Mac OS X.

You can install INDI with the packages provided by your Linux distribution, but as this is a rapidly moving project it is best to get the latest version [http://www.indilib.org/download.html] directly from the project.
For example for Debian/Ubuntu see https://launchpad.net/~mutlaqja/+archive/ubuntu/ppa [https://launchpad.net/~mutlaqja/+archive/ubuntu/ppa]

For Mac OS X the best option is to get the version from CloudMakers [http://www.cloudmakers.eu/xindi/].

There is no INDI server for Windows but you can run CCDciel on Windows to connect to a remote Linux computer. Or use wINDI [http://www.cloudmakers.eu/windi/] to use your ASCOM devices with the INDI protocol.

Astrometry.net

Astrometry.net can be used to solve the image you just take with your camera.

CCDciel need a local copy of the Astrometry.net software and the required indexes on your computer. It can also use the web version using the provided script.

Look at this page http://astrometry.net/use.html [http://astrometry.net/use.html] for instruction to install the software and the data.

Linux

On Linux astrometry.net is probably packaged by your distribution. This is the easiest and preferred way to install the software.
For example on Debian or Ubuntu just do:

```
sudo apt-get install astrometry.net
```

Mac OS X

For Mac OS X the best option is to get the version from CloudMakers [http://www.cloudmakers.eu/xindi/].

Windows

A number of Windows package include a fully automated install of Cygwin and astrometry.net and it is best to get one of them. CCDciel do not use this applications but the astrometry.net they install.

The following list indicate tested application and give the Cygwin path you must configure in the astrometry preferences.
At the time of writing all this application use the same version 0.38 of astrometry.net.

- Astrotortilla [https://sourceforge.net/projects/astrotortilla/], set Cygwin path to C:\cygwin
- ANSVR [https://adgsoftware.com/ansvr/], set Cygwin path to C:\Users\[your user name]\AppData\Local\cygwin_ansvr
- All sky plate solver [http://www.astrogb.com/astrogb/All_Sky_Plate_Solver.html], set Cygwin path to C:\Users\[your user name]\AppData\Local\Astrometry

ELBRUS

Elbrus star locator can be used to solve the image you just take with your camera.

Look at the program page for instruction http://www.astrosurf.com/pulgar/elbrus/elbrusin.htm [http://www.astrosurf.com/pulgar/elbrus/elbrusin.htm]

Before you can use it the Elbrus program must be calibrated for your images. Then select File / E-Wait for message.

Also be sure to set the parameter: “Add the WCS in the FITS header”.

This is a Windows only software but I find it easy to install and use on Linux with Wine.
On the astrometry preference you can set both the DOS and Unix path to the image data to help with this use.

To install Wine on Linux or Mac OS X see Wine web pages [https://www.winehq.org/].

On Linux the best way is to install the wine packages provided by your distribution.

PlateSolve 2

PlateSolve 2 can be used to solve the image you just take with your camera.

Look at the program page for instruction http://planewave.com/downloads/software/ [http://planewave.com/downloads/software/]

Install the program itself and the star catalog. Then configure the program path in CCDciel.

Linux and Mac

This is a Windows only software but it run on Linux with Wine.

Use winetricks to install the required VB6 dependency:

```
winetricks vb6run
```

To install Wine on Linux or Mac OS X see Wine web pages [https://www.winehq.org/].

On Linux the best way is to install the wine packages provided by your distribution.

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