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A2.2. Toolkit: Faulkes and LCO Robotic Telescope Handbook

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This manual provides comprehensive instructions for students on operating the Faulkes and LCO Robotic telescopes, offering step-by-step guidance for efficient utilization and exploration of celestial objects for educational purposes. With clear explanations and practical tips, students will gain valuable hands-on experience in astronomical observation and data collection using this cutting-edge robotic telescope system.

Language: English

Suitable for age: 7-18 years

Key words: Robotic telescopes; Observing, Planning, Data, Archive



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SUBMITTING AN OBSERVATION REQUEST TO THE (SIMPLE) LCO INTERFACE

Instructions

These detailed instructions will guide you in utilizing your Faulkes Telescope account to access the Las Cumbres Observatory (LCO) interface in 'Basic' mode. You'll learn how to submit an observation request for an object of your choosing step-by-step. In case you do not have a telescope account, please apply for one.

Step 1: To submit an observation on the Faulkes Telescope using the LCO network you will need to follow the link here: <https://observe.lco.global/>. This will take you to the screen shown in **Figure 1**.

Step 2: Select one of the 'Login' options circled in Figure 1 and input your username and password. Your username is usually your email address.

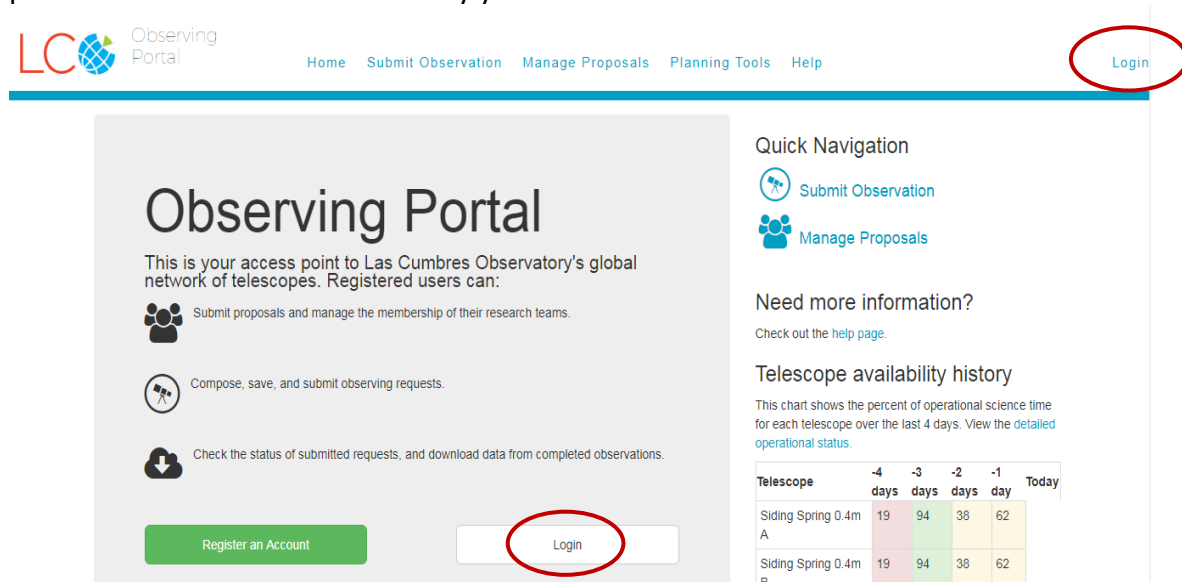


Figure 1 – Logging on to LCO’s observing portal

Step 3: You will be able to see if you are in 'Basic' mode by looking next to your name in the top right of the screen. If it does not say 'Basic Mode', you will need to turn this on. Do this by clicking on your **name**, then **profile** (Fig. 2) and select **“Use Basic Mode”** at the bottom of the page (Fig. 3).

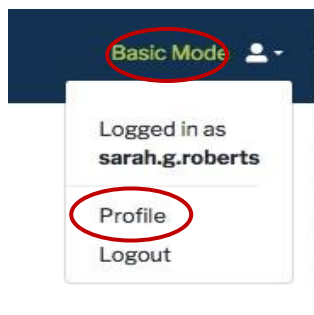


Figure 2 – Entering your profile in the LCO system.



Use Basic Mode

Hide advanced fields on the request composition page.

Figure 3 – Selecting the simple interface option to use the Basic mode.

Then click on **“Save”** at the bottom of the page.

You can also select **“View authored requests only”**, then you will only see your own requests on the main page, and not everybody’s observations.

Step 4: You’ll now be taken to a page that displays a lot of information. You don’t need to worry about most of this, just simply select **‘Submit Observation’** to request your observation as shown in Figure 4.

The screenshot shows the Observing Portal interface. At the top, there is a navigation bar with links: Home, Submit Observation, Manage Proposals, Planning Tools, Help, and a user profile 'sophie.'. Below the navigation bar is a table titled 'Submitted Observation Requests'. The table has columns for 'User Info', 'State Info', and '# Requests / Pending / Failed / Complete'. There are five rows of requests, each with a telescope icon, a name, a user name, a state (all 'PENDING'), a timestamp, and a row of four numbers (1, 1, 0, 0). To the right of the table is a 'Quick Navigation' section with two buttons: 'Submit Observation' (circled in red) and 'Manage Proposals'. Below this is a section 'Need more information?' with a link to 'help page'. At the bottom right is a 'Telescope availability history' chart showing the percentage of operational science time for each telescope over the last 4 days.

Telescope	-4 days	-3 days	-2 days	-1 day	Today
Siding Spring 0.4m A	19	94	38	62	

Figure 4 – Where to go to submit your observation.

Your screen should now display the Observation Request Form. The following steps will take you through each section of this form.

Don’t panic if you see a lot of red error messages on the page. These will remain until you have completed all the information boxes.

General Information Section

This is the general summary section of your observation request (Fig. 5).

Step 5: In the **‘Name’** box you should give your observation a suitable title that you will remember.

You may want to use your **name or initials** so that you can find your images easily once they’ve been taken.

Step 6: ‘Proposal’ refers to the telescope proposal you wish to take the observation time from. You should select **‘FTP Education – Queue’**.



Figure 5 – General information section of the observation request form

Request Section

Step 7: Next, we have the Request section (Fig. 6). Here you should select the instrument you wish to use. You can choose from the three sizes of telescopes, 2-metre, 1-metre or 0.4-metre. For example, the **2.0-meter MuSCAT** option is for FTN (Hawaii) and FTS (Australia) and the name describes the name of the camera on these telescopes. The first MuSCAT camera was installed in April 2021 and enables the user to take 4 images simultaneously during one observation (g,r,i,z bands), so you won't see the 'Filter' option available to you later on in the page. For more information on MuSCAT3, please go to the [MuSCAT3 page on the LCO website](#).

Figure 6 – Request section of the observation request form



Instrument Configuration

The instrument configuration is where you fill in the details of the filters, exposure times and where applicable, readout mode and exposure mode. The boxes you fill out here depend on which instrument you have selected to use from the previous section and each option is shown in the highlighted boxes below:

0.4meter SBIG

The screenshot shows a web interface for instrument configuration. The title bar reads 'Instrument Configuration'. On the left side, there is a link: 'Try the online Exposure Time Calculator.' On the right side, there are three input fields: 'Exposure Count' with the value '1', 'Exposure Time?' with the value 'NaN', and 'Filter' which is empty. A small green icon with a document symbol is circled in red in the top right corner of the window.

Figure 7 – Instrument configuration section of the observation request form for 0.4-meter SBIG

Step 08: Leave 'Exposure Count' on 1 (this is the number of images you will take) and enter your 'Exposure Time'. If you're unsure on what exposure time to use, you can follow the link to the LCO online Exposure Time Calculator provided on the left side of the configuration section, or you can search the LCO data archive to see what other users have selected for the same object (see below).

Step 09: Now select the **filters** you wish to use. If you want a **colour image** you will need to select the **Blue, Green and Red** filters.

You can only select one filter at a time so begin by selecting 'Blue'.

Step 10: To **add another filter**, you will need to click the **little green icon** at the top of the window circled in red in the Figure above this is '**Copy**'. It will replicate the details you have just inputted so you will need to change the filter, for example to Green and adjust the exposure time if you need to.

You can then repeat this for however many filters you wish to use.



0.4meter SISCAM QHY600

Instrument Configuration

- Try the [online Exposure Time Calculator](#).

Exposure Count: 1

Exposure Time: 120

Readout Mode: QHY600 Full Frame Readout

Filter: Blue

Figure8 – Instrument configuration section of the observation request form for 0.4-meter SBIG

Step 11: Leave 'Exposure Count' on 1 (this is the number of images you will take) and enter your 'Exposure Time'. If you're unsure on what exposure time to use, you can follow the link to the LCO online Exposure Time Calculator provided on the left side of the configuration section, or you can search the LCO data archive to see what other users have selected for the same object (see below).

Step 12: Readout Mode: For better optical performance, select the extended full frame readout mode, meaning the QHY600 can achieve a greater full well of more than 80ke-. This gives a better dynamic range and large variations in magnitude of brightness are less likely to saturate.

Step 13: Now select the **filters** you wish to use. If you want a **colour image** you will need to select the **blue, green and red** filters.
You can only select one filter at a time so begin by selecting 'Blue'.

Step 14: To **add another filter**, you will need to click the **little green icon** at the top of the window circled in red in the Figure above this is 'Copy'. It will replicate the details you have just inputted so you will need to change the filter, for example to Green and adjust the exposure time if you need to.

You can then repeat this for however many filters you wish to use.



1.0-meter Sinistro

The screenshot shows the 'Instrument Configuration' section of the observation request form for the 1.0-meter Sinistro instrument. The form is titled 'Instrument Configuration' and has a camera icon and a green checkmark on the left. On the right, there is a blue minus sign and a green square icon with a white document symbol, which is circled in red. The form contains the following fields:

- Exposure Count: 1
- Exposure Time: NaN
- Readout Mode: 1M Sinistro Full Frame
- Filter: (empty)

Figure 9 – Instrument configuration section of the observation request form for 1.0-meter Sinistro

Step 15: Leave 'Exposure Count' on 1 (this is the number of images you will take) and enter your 'Exposure Time'. If you're unsure on what exposure time to use, you can follow the link to the LCO online Exposure Time Calculator provided on the left side of the configuration section, or you can search the LCO data archive to see what other users have selected for the same object (see below).

Step 16: The readout mode can be left as '1M Sinistro Full Frame'.

Step 17: Now select the **filters** you wish to use. If you want a **colour image** you will need to select the **Blue, Green and Red** filters.

You can only select one filter at a time so begin by selecting 'Blue'.

Step 18: To **add another filter**, you will need to click the **little green icon** at the top of the window circled in red in the Figure above this is '**Copy**'. It will replicate the details you have just inputted so you will need to change the filter, for example to Green and adjust the exposure time if you need to.

You can then repeat this for however many filters you wish to use.



2.0-meter Muscat

The screenshot shows the 'Instrument Configuration' section of a web form. At the top left, there is a camera icon and a green checkmark. The title 'Instrument Configuration' is centered at the top. Below the title, there is a link: 'Try the [online Exposure Time Calculator](#).' The form contains several input fields and dropdown menus:

- Exposure Count: A text input field containing the number '1'.
- Exposure Mode: A dropdown menu with 'Synchronous' selected.
- Exposure Time g: A text input field containing 'NaN'.
- Exposure Time r: A text input field containing 'NaN'.
- Exposure Time i: A text input field containing 'NaN'.
- Exposure Time z: A text input field containing 'NaN'.
- Readout Mode: A dropdown menu with 'Muscat Fast Readout' selected.
- Filter: A dropdown menu that is currently empty.

Figure 10 – Instrument configuration section of the observation request form for 2.0-meter MuSCAT (FTN, FTS)

Step 19: Leave 'Exposure Count' on 1 (this is the number of images you will take) and choose 'Synchronous' exposure mode. This starts taking all the images at the same time.

Step 20: Now choose the exposure times for each filter (g, r, i and z). For the first trials you can choose 60 seconds to 120 seconds for each filter. For the experienced users: If you're unsure on what exposure time to use, you can follow the link to the LCO online Exposure Time Calculator provided on the left side of the configuration section, or you can search the LCO data archive to see what other users have selected for the same object, (see below).

Step 21: The Readout Mode can be left as 'Muscat Fast Readout'.

NB. If a 'filter' option appears at the end of this section, it can be ignored as it is not used for the MuSCAT camera.



Target Section

The target section is where you fill in the details about the object you wish to image.

Figure 11 – Target section of the observation request form

Step 22: If you know the Messier or NGC number of your object, you should insert it in the **'Name'** box. This makes it more likely that the scheduler will be able to find the right ascension and declination for you automatically.

If the right ascension and declination values do not come up automatically, you will need to enter them yourself. You can search these coordinates on Stellarium (<https://stellarium.org>) or through a Google search of your object. The small question mark in front of the "Right Ascension" and "Declination" boxes show you the format how to insert this data. If your object has e.g. the coordinates 05h 35m 16,5s in Right Ascension and -05° 23' 23" Declination, you need to enter "05:35:16.5" and "-05:23:23".

Window

We now move onto the Window section. This describes the **time window** in which you would like your observation to be made (Fig. 11).

Step 23: The time is set to Universal Time and the **Start time will default to the current time**. We recommend putting your **End time a week later**. This should be enough time for you observation to be made and not be cancelled due to either telescope or camera problems or bad weather.

If you're lucky, the scheduler may even plan a time to image your object as little as 15 minutes after submitting your request. However, this can also change as other requests come in, so keep checking.

The graph that appears as displayed in Figure 11 shows you the visibility of your target in the time window you have set.

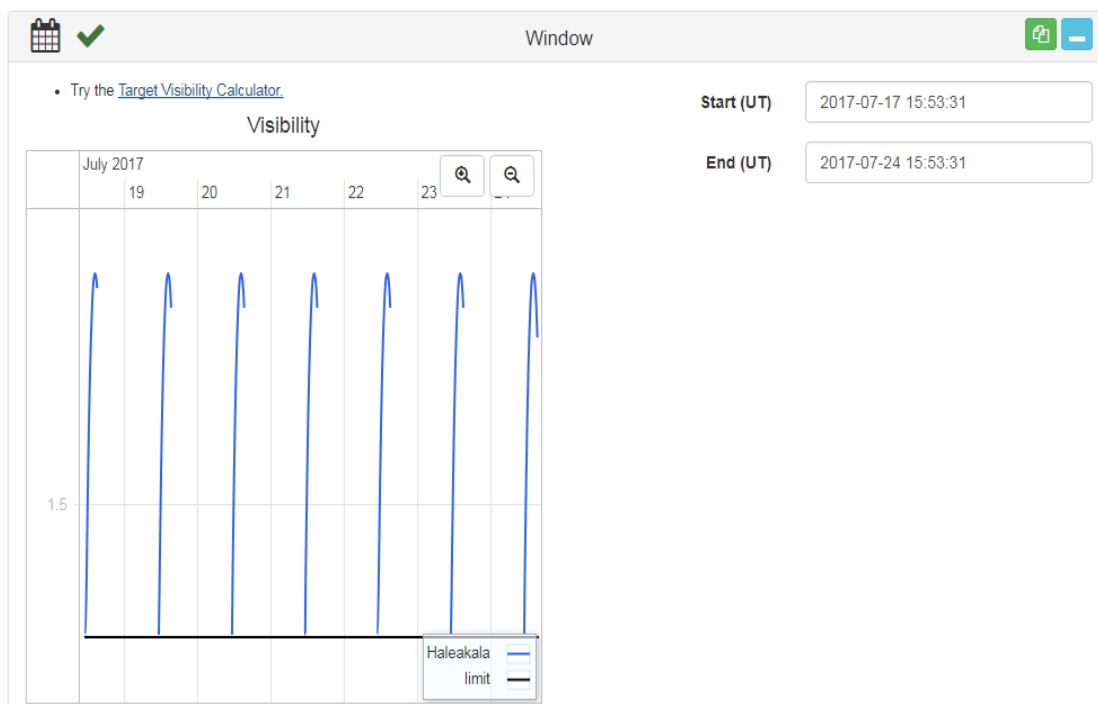


Figure 12 – Window section of the observation request form

You have now completed the observation request form. If you scroll back to the top of the page, it will tell you the duration of your request. This describes how much observing time it will take to take your observation.



Figure 13 – Duration of your observing request

Step 24: If you would like to request observations of **more than one object**, you should scroll back to the **‘Request’** section. First, select the little blue icon in the top-right corner – this is minimised. Then select the **green copy icon**.

You should notice that this causes **‘Request #2’** to appear on the right-hand side of your screen as seen in Figure 13.

- ✓ General Info
- ✓ Request #1
- ✓ Request #2

Figure 14 – Your different requests within your observation request form



Step 25: By clicking on Request #2, this will take you to your **replicated request**. The boxes will already be completed with the information you submitted for your Request #1 so you will need to **change this according to the additional object you wish to observe**.

Step 26: When you are happy with your requests and have completed the form, scroll back to the top of the page, and select the green **'Submit Request'** button. This will process your request and it will go into the telescope network scheduler.

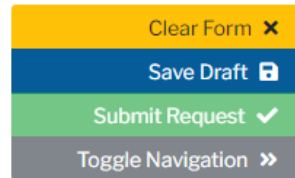


Figure 15 – Submitting your observation request form to the LCO telescope scheduler.

Step 27: This will cause a **pop-up** that asks if you are sure you want to submit your request, you should select **'OK'**.

If this message does not pop-up, you may need to enable pop-ups in your internet settings.

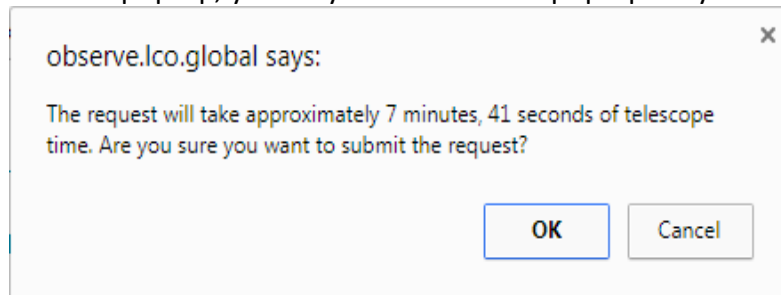


Figure 16 – The request submission pop-up

All you need to do now, is come back in a week's time (or how over long you set your time window as) to retrieve your images.

For further information, contact support@faulkes-telescope.com



LCO ROBOTIC TELESCOPE – OBSERVATION PLANNING SHEET

Instructions

This document can be used as a template for planning an observing session with the LCO robotic telescopes.

Planning checklist:

- Make an FTP/LCO account.
- Choose your observation window.
- Select an object that is visible within your observation window.
- Select a telescope aperture based on the object's angular size and the camera's field of view.
- Select an exposure time based on the object's magnitude and telescope size.
- Select what filters you want to observe the object with.
- Fill out the table below with all the details of your chosen object.

Observation window (Start and end dates):

Phase of Moon:

Object Name & Type	RA(J2000)	Dec (J2000)	Size (Arcmin)	Magnitude	Telescope to be used	Filters to be used	Exposure time (s)



LCO ROBOTIC TELESCOPE OBSERVATION PLANNING STEPS

Introduction

This document outlines the procedures necessary for planning an observing session with the LCO robotic telescopes. Derived from the content available on LCO's website at <https://lco.global/education/activities/preparing-an-observation-request-on-lco/>, this guide provides step-by-step instructions for preparing an observation request.

Background

Las Cumbres Observatory (LCO) is a global telescope network consisting of two 2-metre telescopes, thirteen 1-metre telescopes, and ten 0.4-metre telescopes.

Requests on the LCO network do not identify specific sites or telescopes – instead, you choose which telescope aperture class or size (e.g. 0.4 m telescope) to use. LCO's scheduling software assigns each observation request to the best telescope available and reassigns it to the next available telescope if the initial attempt fails (due to weather or technical problems).

The LCO network is used by thousands of astronomers, communicators, educators, and students around the world. To ensure telescope time is used efficiently, it's essential that users take the time to adequately prepare before scheduling observations. The steps below will help you do this:

Steps

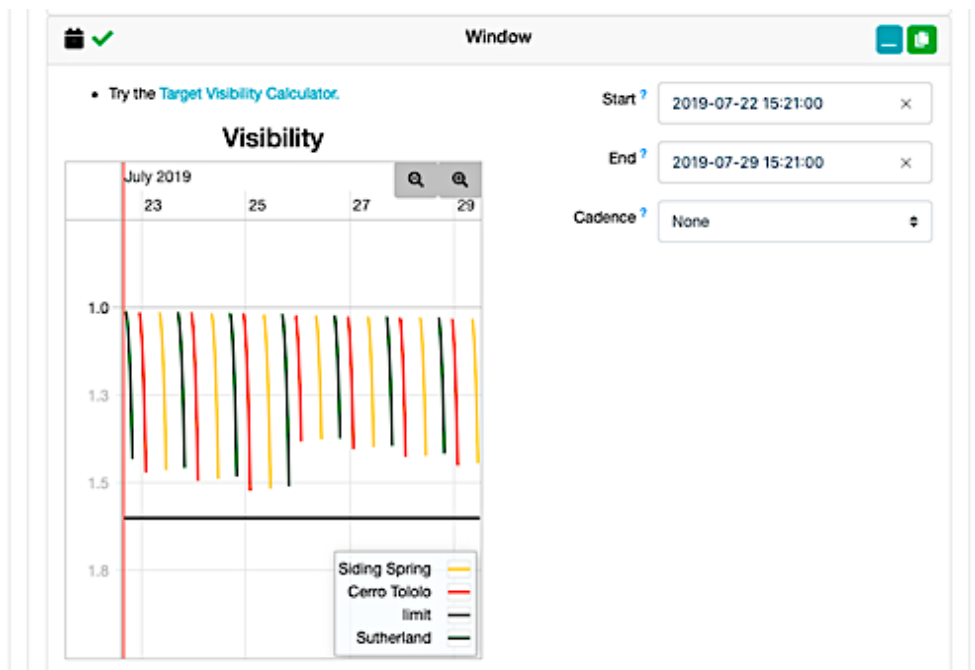
Step 1: Define your Observation Window – Select the time period within which you'd like your observations taken. We recommend a minimum length of one week. Enter the time window on your **Observation Planning Sheet** if you are using one.

Step 2: Select a visible object – In Stellarium (<https://stellarium.org>), set the date and time to when your Observation window will start. Set the location to match the location of one of your potentials chosen telescopes (e.g. if you wanted to use a 1m telescope, choose one of the locations where there is a 1m telescope).

Stellarium will now display the sky that will be visible from your chosen observatory location during your time window. Search for a selection of deep sky objects, ideally, that are located at least 30 degrees above the horizon. To see more information on each object, click on it in Stellarium. This will pop up information such as its angular size, magnitude, name, type, and coordinates. Enter any relevant information for each potential object on your Observation Planning Sheet if you are using one.



LCO Visibility Plot: When scheduling your observations on the LCO queue, after you have defined your time window, a plot will appear showing the visibility of your target object at each observatory location during this period. Each site is coded with a different colour and visibility is shown as the change in airmass (essentially, the amount of atmosphere through which light from the object must travel) of the object over time.)



Step 3: Check object dimensions – The area of sky visible through a telescope at any one time is called its ‘Field of View’ (FOV). When choosing your object, keep in mind the field of view of the camera aboard your selected LCO telescopes. Information about the cameras and telescope size can be found in the table below.

Telescope class (size)	Camera (instrument) name	Field of View (arcmin)
2 meter	MuSCAT	9.1 x 9.1
1 meter	Sinistro	26 x 26
0.4 meter	SBIG 6303	29 x 19

The dimensions of your object(s) can be found by clicking on the object in Stellarium.

Step 4: Select a suitable exposure time - The exposure time is how long the telescope shutters stay open to collect light from your object. A suitable exposure time must be selected: if the exposure time is not long enough, the object will appear too faint, while over-exposure leads to saturation and loss of detail.



Suitable exposure times can be found by looking at previous observations of your object in the LCO archive and seeing which ones gave good results:

- Go to <https://archive.lco.global/>
- Enter the name of your object in the **Point** field.
- Set the date range to “**All time**” using the calendar at the top of the left menu.
- Set the **Telescope** field to match the size of the telescope you will be using.
- You will see the exposure times (**Exp. Time**) for any listed observations and can look at the images to see which are under/overexposed or just right.

Step 5: Select suitable filters – Each telescope class has different filter sets available – these are detailed in the table below. If you are just interested in making a colour image then we recommend you take an image with the red, green and blue filters (N.B. the MuSCAT camera on FTN has fixed filters and takes an image using all filters at the same time, so on this telescope you cannot choose a filter).

Telescope class (size)	Camera (instrument) name	Filters options
2 metre	MuSCAT	SDSS g,r,i,z (fixed)
1 metre	Sinistro	21
0.4 metre	SBIG 6303	9

Step 6: Schedule your observations – once you know what telescope size, object, exposure time and filter you plan to use, you are ready to go onto the [LCO observing portal](#) and schedule your observations – good luck and happy observing!



ACCESSING THE LCO DATA ARCHIVE

Instructions

This document explains how to access the LCO data archive.

1. Signing In

You should begin by signing in to the archive using the same username and password you use to access the observatory portal.

2. Date (calendar)

This specifies the time period from which results will appear. The default is this semester and there are several other pre-defined date ranges to choose from. If you need a more specific time range, choose "Custom Range" or the easiest option is to select "**All Time**".

3. Proposal

This is the proposal from which the observations are made. If you are logged in, your proposals (all beginning with FTP) will appear at the top, under 'My proposals'. However, we recommend leaving this on '**All**'.

4. Basename

This is the name of the file that is created when your image is taken. We don't recommend using this search field.

5. Point

The point field allows you to search for an **object by its position** on the sky. Entering an object name (eg. M42) in the Lookup field will use an online service to search for the object and populate the **RA and Dec** (coordinates) search fields automatically. You can also manually enter a position.

6. Object

This searches for an object as it is named in the FITS header. It is not an exact match and we do not recommend using this search box.

7. Obstype

This refers to the type of observation you are looking for. You will want the '**EXPOSE**' option which describes an image exposure.

8. Reduction Level

This describes how much processing the data has been through. You will want to select '**Reduced (BANZAI)**'.

Raw files have undergone no processing and Quicklook files have undergone processing but only with calibration frames that were available at the time. Reduced



files have undergone processing with the most suitable calibration frames and will show the most clear-cut image of your target.

9. Site

This is the telescope site at which the observation was made:

lsc:	Chile	Cerro Tololo Interamerican Observatory
bpl:	California	Back Parking Lot
coj:	Australia	Siding Spring Observatory
cpt:	Sutherland	Astronomical Observatory
elp:	Texas	McDonald Observatory
ogg:	Hawaii	Haleakala Observatory
sqa:	California	Sedgwick Reserve
tfn:	Tenerife	Teide Observatory

10. Telescope

This is the telescope class (or size) with which the observation was made:

0m4 options are the 0.4-metre telescopes.

1m0a are the 1-metre telescopes.

2m0a are the 2-metre telescopes.

11. Instrument

This is the camera that was used to take your image. It is unlikely you will know this and there are a lot of options! You should leave this set to '**All**'.

12. Filter

This is the filter that was used when making your observation. If you have done a colour image you will want to select '**B**', '**V**' and '**R**' for blue, green, and red respectively, (make sure you choose the ones in Caps Lock). However, if you have taken your images on a 0.4-metre telescope you will need to select '**rp**' for red. You can only search each filter individually.

13. Exposure Time

This is the **exposure time** of your observation in **seconds**. This will retrieve images with exposures equal to or greater than the value you input.

14. Reset

If you want to reset all the fields in your search, click this button.

15. Expanding Selection

By clicking on the **+** sign next to an image you can see a preview of what the image looks like and what calibration was carried out.

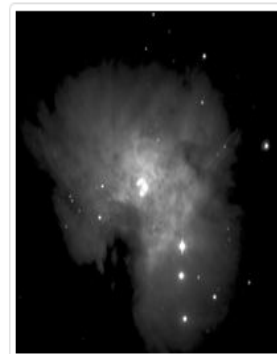


<input checked="" type="checkbox"/>	<input type="checkbox"/>	coj2m002-fs01-20170830-0052-e91	2017-08-30 19:05:38	FTPEP02014A-004	M42	V	EXPOSE	90.000	Reduced (BANZAI)
-------------------------------------	--------------------------	---------------------------------	------------------------	-----------------	-----	---	--------	--------	------------------

Calibration and Catalog Frames

VIEW HEADERS

	Basename	Type
<input type="checkbox"/>	dark_fs01_20170830_bin2x2	DARK
<input type="checkbox"/>	bias_fs01_20170830_bin2x2	BIAS
<input type="checkbox"/>	coj2m002-fs01-20170830-0052-e00	EXPOSE
<input type="checkbox"/>	skyflat_fs01_20170828_bin2x2_V	SKYFLAT
<input type="checkbox"/>	bpm_coj_fs01_20150809_bin2x2	BPM



16. Downloading Data

If you want to download images, tick the small box **to the left of the Basename of the image(s)** you want (as circled above) and click the blue **'Download'** button. There are 2 options which you can choose:

1. zip download (with compressed fits files) or
2. zip download (with uncompressed fits files).

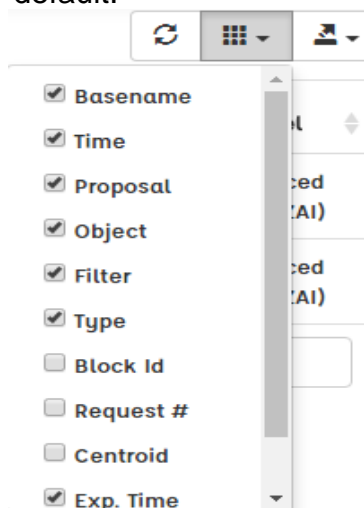
If you choose option (1) then your files will be the **".fits, .fz"** format and whatever software package you use to open the files must be able to display .fz files. If you choose option (2) then your file sizes will be larger, but you can use any software package that opens **.fits** files to open your data.

17. Refresh, Table and Export



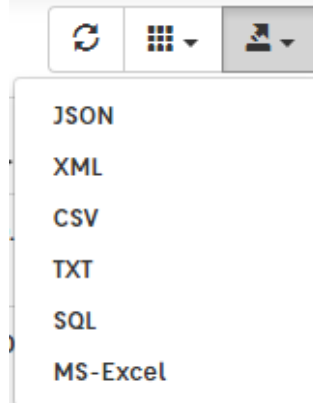
This is the **refresh** button; it will reload the data in the table whilst **preserving the search filters** you have set.

Here you can select which columns you want to be **displayed in the data table**. Some columns are hidden by default.





Here you can **export the table** of data in a variety of formats.



Example

If you wanted to search the data archive for **all public data** on **M51**, the Whirlpool Galaxy, taken with a **2m telescope** over **all time**, you would set the following values:

2000-01-01 00:00
2021-05-25 23:59

Proposal ?
All

Include public data

Basename

Looking for an object? **Point**
?

M51

13:29:52.69 +47:11:42.9

Object ?

Obstype
EXPOSE

Reduction Level ?
Reduced (BANZAI)

Site
All

Telescope
2m0a

Instrument
All

Filter
All


Exposure Time ?

All time

Enter 'M51' and click on the magnifying glass



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Las Cumbres Observatory
Science Archive

Documentation [Api](#) [Lco-global](#)

	+ Basename	Time	Proposal	Object	Filter	Type	Exp. Time	R.level
+	trnOmiat-Kb29-20170904-0194-d00	2017-09-05 07:25:22	calibrate		B	DARK	299.824	Raw
+	trnOmiat-Kb29-20170904-0193-b00	2017-09-05 07:25:10	calibrate		B	BIAS	0.001	Raw
+	trnOmiat-Kb29-20170904-0192-b00	2017-09-05 07:25:01	calibrate		B	BIAS	0.001	Raw
+	trnOmiat-Kb29-20170904-0191-b00	2017-09-05 07:24:52	calibrate		B	BIAS	0.005	Raw
+	trnOmiat-Kb29-20170904-0190-b00	2017-09-05 07:24:43	calibrate		B	BIAS	-0.002	Raw
+	trnOmiat-Kb29-20170904-0189-b00	2017-09-05 07:24:34	calibrate		B	BIAS	0.012	Raw
+	trnOmiat-Kb29-20170904-0188-b00	2017-09-05 07:24:25	calibrate		B	BIAS	0.004	Raw
+	trnOmiat-Kb29-20170904-0187-b00	2017-09-05 07:24:17	calibrate		B	BIAS	0.005	Raw
+	trnOmiat-Kb29-20170904-0186-b00	2017-09-05 07:24:08	calibrate		B	BIAS	0.002	Raw
+	trnOmiat-Kb29-20170904-0185-b00	2017-09-05 07:24:00	calibrate		B	BIAS	0.004	Raw

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