hcam-finder Documentation

Release 0.4.9

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Contents

Observation planning and finding charts for HiPERCAM

IMPORTANT: as of v0.4.8 hcam_finder has the correct rotator centre and offset for the GTC. If you installed prior to this, make sure you delete the config file '~/.hfinder/config' and update to the latest version.

`hcam_finder` provides a Python script `hfinder` for observation planning with HiPERCAM on the WHT and GTC. It allows you to generate finding charts as well as specify the instrument setup you require, whilst providing an estimate of observing cadence, exposure time and S/N estimates.

`hcam_finder` is written in Python and is based on TKinter. It should be compatible with Python2 and Python3.

Installation

The software is written as much as possible to make use of core Python components. It requires my own [hcam_widgets](#) module. It also relies on the third party libraries [astropy](#) for astronomical calculations and catalog lookup, as well as [ginga](#) for image display. Optionally, you can also use [astroquery](#) to expand the range of surveys one can download images from.

Installing using `pip` should take care of these dependencies. Simply install with:

```
pip install hcam_finder
```

or if you don't have root access:

```
sudo pip install hcam_finder
```

or:

```
pip install --user hcam_finder
```

- Free software: MIT license

- Documentation: https://hcam-finder.readthedocs.io.

CHAPTER 2

Bugs

`hfinder` is of course entirely bug free! However, if you do find an issue, please raise it at the github page.
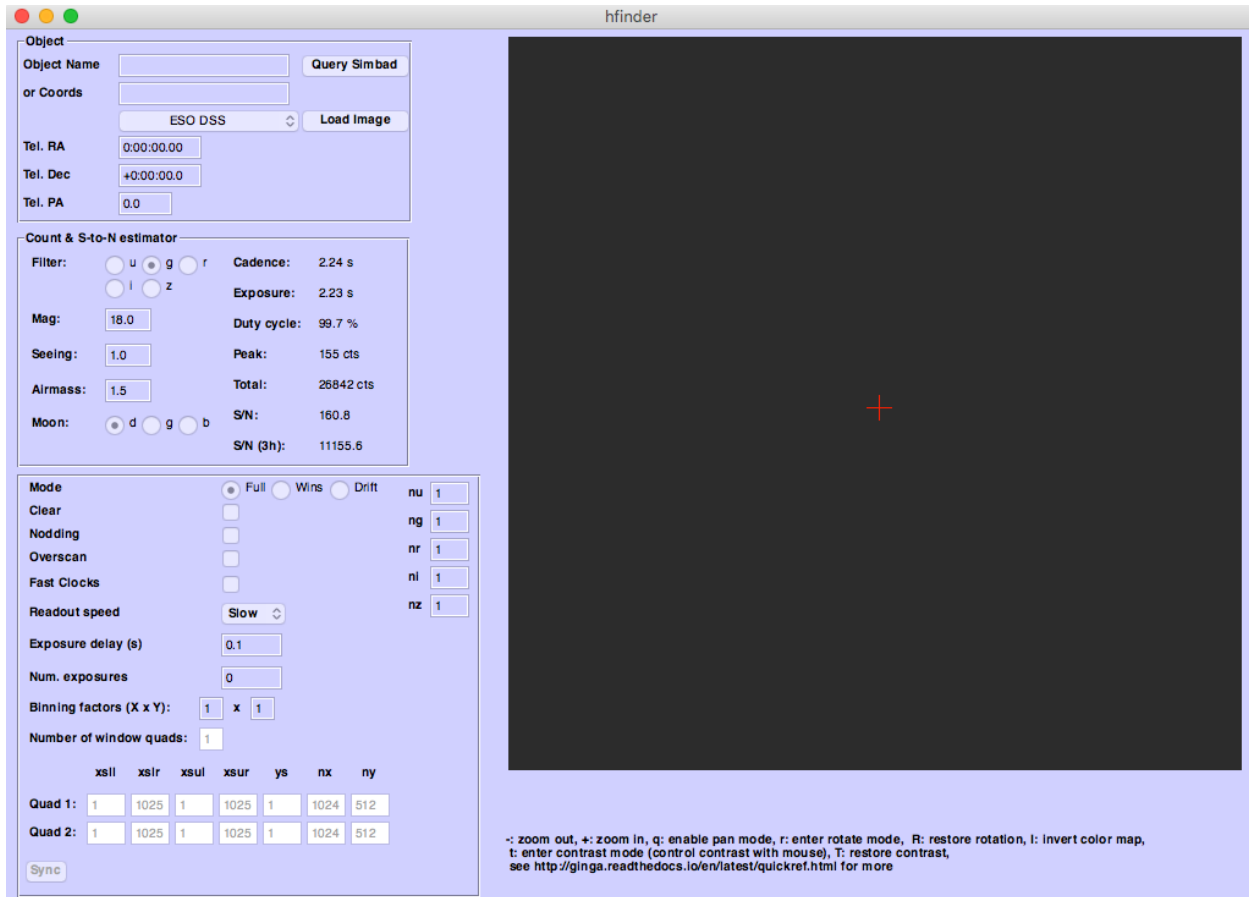
Usage

Please see the *detailed usage instructions*

3.1 Usage

To start `hfinder`, simply type:

```
hfinder
```

The main GUI window will display, shown below.

3.1.1 Telescope Selection

Before proceeding any further, make sure the correct telescope is selected using the *Telescope* menu item. If you wish to make your selection permanent, see *Changing the config file*.

3.1.2 Target Setup

Enter your Object Name in the appropriate box. You can query SIMBAD using your entered target name by pressing the *Query Simbad* button. If SIMBAD lookup fails, you can enter your target coordinates by hand.

Select a sky survey to grab images from and press the *Load Image* button. If an image is available in the selected sky survey it will be downloaded and displayed, along with the HiPERCAM field of view (FoV).

3.1.3 Manipulating the FoV

You can change the telescope pointing either by click-dragging the FoV, or by changing the values in the *Tel. RA* and *Tel. Dec* fields. Like all numerical entry boxes in `hfinder` the right and left arrow keys will increment or decrement the values. Holding `Shift` whilst pressing the arrow keys will make larger changes.

The Sky PA can be click-dragging on the corner of the displayed FoV. This will rotate the FoV. Alternately, edit the value in the *Tel. PA* field.

3.1.4 Interacting with the displayed image

Basic instructions for manipulating the displayed image (pan, zoom etc) are displayed below the image itself. `hfinder` uses the ginga package for image display. For a fuller reference about interacting with the image area, see the Ginga Quick Reference.

3.1.5 Choosing an Instrument Setup

`hfinder` includes a panel that is used to configure the readout modes of HiPERCAM. This panel is shown below:

As you make changes to this panel, the displayed FoV will update to reflect your choices of readout mode and window settings. The exposure time, cadence and signal-to-noise estimates in the panel above will also update.

Use this panel to select an instrument setup that best suits your observing needs. For a description of the various settings and HiPERCAM's available modes, see *Using HiPERCAM*.

Once you've got a setup and a pointing you are happy with, you can save a finding chart and export an instrument configuration file. To do this, select *Save → Finding Chart* and *Save → Inst. Setup File* respectively. This will create two files which you should upload as part of your phase II submission.

3.1.6 Changing the config file

A default configuration is written to `.hfinder/config` in the user's home directory. This has many settings in it, the vast majority of which should not normally be changed by the user. Two which are of interest are `telins_name`,

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which sets the default telescope. Set this to `GTC` or `WHT` as required.

The other option which may be useful is the `font_size`. Change this setting to increase or decrease the font size if the GUI does not fit well on your screen.

3.2 HiPERCAM

The primary consideration when observing with HiPERCAM is to realise that its frame-transfer CCDs have no shutter. Instead, an image is rapidly moved into the storage area, which begins a new exposure in the image area. The image continues to expose whilst the storage area is reading out; this sets a *minimum exposure time* equal to the time needed to readout an image.

For a full-frame image with slow readout speed, this minimum exposure time is around 2.1 seconds. Longer exposures can be obtained by entering an *Exposure Delay*, but shorter exposures will require the use of *Windowed mode*, *Drift mode* or *Clear mode*.

3.2.1 Outputs

HiPERCAM has four seperate outputs, or channels, per CCD. The division between these outputs is clearly shown in the FoV in `hfinder`. Each of these outputs has slightly different gains and bias levels; **avoid putting critical targets on the boundary between outputs**.

3.2.2 Windowed mode

To enable higher frame rates, HiPERCAM can use one or two windows per output. Since there are four outputs, we refer to *window quads* to define window settings. You can enable windowed mode by selecting *Wins* for the *Mode* option in the instrument setup panel.

A window quad is defined by the x-start positions of the four quadrants, the size of the windows in x and y, and a y-start value. All windows in a quad must be the same shape, and all share the same y-start value. Increasing y-start moves the windows in from the edges of the CCD towards the centre.

If there are two window quads, they cannot overlap in y.

Synchronising windows

If on-chip binning is enabled, it is possible to define windows that do not align with the boundarys of the binned pixels. This is fine, but it does mean that one cannot bin calibration frames taken with 1x1 binning (such as sky flats) to match the windowed data. If windows are not synchronised in this manner, the *Sync* button will be enabled. Clicking this will align the windows with the boundaries of binned pixels.

3.2.3 Clear mode

Sometimes extremely short exposures are needed, even with full frame data. Sky flats would be one example. It is possible to *clear* the image area of the CCD, just after the storage area is read out. This allows exposure times as short as 10 microseconds. These short exposures come at the expense of efficiency, since the charge accumulated whilst the storage area was reading out is lost.

For example, if the storage area takes 2s to read out, clear mode is enabled and the exposure delay is set to 1s, then an image would be take every 3s with a duty cycle of 30%.

As a result, if the user needs short exposure times to avoid saturation, it is often preferable to use a faster readout speed, *Windowed mode* or *Drift mode* to achieve this without sacrificing observing efficiency.

Clear mode is enabled by selecting the *Clear* checkbox.

3.2.4 Drift mode

Drift mode is used to enable the highest frame rates. Instead of shifting the entire image area into the storage area at the end of each exposure, only a small window at the bottom of the CCD is shifted into the storage area. This minimises the dead time involved in shifting charge to the storage area and allows frame rates of ~1 kHz for relatively small windows.

In drift mode, a number of windows are present in the storage area at any one time. At the same time, any charge in pixels above the windows is eventually clocked into the windows, and becomes part of that frame. To prevent bright stars from contaminating the drift mode data, a blade is inserted into the focal plane, blocking off most of the image area of the CCD. Because the windows in drift mode spend longer on the chip, they accumulate dark current; drift mode should only be used for frame rates faster than ~10 Hz as a result.

For more information about drift mode, see the ULTRACAM instrument paper and it's appendix.

3.2.5 Exposure multipliers

The instrument setup will determine the exposure time and cadence of your data. It is unlikely that this exposure time will be optimal for your target in all bands. Many objects will need longer exposures at the blue or red extremes. HiPERCAM supports *exposure multipliers*. These allow a CCD to be readout once every N exposures, and can be changed in the fields labelled *nu*, *ng*. . .

With, for example, nu=2, the u-band CCD will read out every two frames. This allows you to double the exposure time for the u-band CCD only. Note that the S/N estimates in `hfinder` do *not* take account of the exposure multipliers.

3.2.6 Miscellaneous settings

The remaining settings you can change are described below:

Num. exposures The number of exposures to take before stopping. Most HiPERCAM users will want to take a continuous series of exposures and stop after an alloted time. In which case this field should be set to 0.

Readout speed Fast readout speed reduces the minimum exposure time in full-frame readout from 2.2s to 1.3s. This comes at the expense of increased readout noise. The impact of this on the S/N of your target is shown in `hfinder`.

Fast clocks Users wanting the ultimate in high speed performance can enable this option. This increases the rate at which charge is clocked in the CCDs. It will have an impact on charge transfer efficiency. As of today, this impact has not been well characterised, but we do not think it is serious.

Overscan Enable the recording of the overscan regions at the left and right edges of the chip. Can be useful if precise measurement of the bias in each frame is needed. This is important for the highest levels of photometric precision, so consider this option for, e.g. exoplanet transit observations.

3.2.7 Nodding the Telescope

It is possible to nod the telescope between frames. This can be useful if, for example, you want to make a flat-field directly from the night sky observations themselves. *Clear mode* is always enabled when nodding the telescope, to avoid trails from bright stars appearing in the image.

The overheads involved in moving the telescope mean that there is little point in using any mode other than full-frame readout with this option.

If you wish to nod the telescope, check the *Nodding* checkbox. You will be prompted for a plain text file specifying the offset pattern you require. The format of this file is a simple list of *absolute* RA, Dec offsets in arcseconds as shown below:

```
0    0
0    20
20  20
20  0
0    20
```

This offset pattern will be repeated until your exposures are finished. At the moment, there is no way to display the nodding pattern in `hfinder` itself, but `hfinder` will estimate the impact of nodding on your cadence and overal signal-to-noise. Until HiPERCAM is commissioned on-sky, these estimates will be quite crude.

CHAPTER 4

Indices and tables

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