Observing on the Isaac Newton Telescope

This document is based on an earlier document (in Dutch) written by Paul van der Werf and provides background information on the planning and execution of observations on the INT on La Palma.

When you read this document you have presumably decided what you want to observe and why. This document will help you with the 'how', namely the practical planning of observations. As part of this process you might discover that you need to make some adjustments to your plans. While that can be frustrating it is completely normal also when we write actual observing proposals.

The technical part of the observing proposal

So, you have now decided what you want to observe. Your task now is to translate your aims into something that can be carried out in practice at the telescope. There are four main questions you should address:

1. When is the object visible?
2. In what filter do you want to carry out the observations?
3. What exposure time do you need to carry out your observations?
4. How many observations/exposures do you need and with what sampling in time (what we call "cadence")?

In order to answer these questions you need some more information about the facilities we have available. There are of course some situations where you might not be able to decide all of this before going to the telescope (if you want to observe transient sources for instance) but that only means that you would need to do this on short notice at the telescope so you should go through this before going regardless.

The Wide Field Camera on the Isaac Newton Telescope

The INT is a Cassegrain telescope with a 2.5m mirror and until the beginning of the 80s it was one of the bigger telescopes in the world - at the time of construction it was the 5th largest. It was built in the 60s and saw first light in 1967 - but at that time the telescope was located at Herstmonceux in the United Kingdom. This turned out not to be a particularly good place to have a telescope so in 1979 it was transported to La Palma to become part of the Dutch/British observatory there - the Isaac Newton Group on Roque de Los Muchachos. It started operations there in 1984.

Figure 1: The INT building at Herstmonceux (credit: Wikipedia)

The observatory has expanded significantly since the beginning in the 80s and now hosts a range of telescopes with the largest being Grantecan, the Spanish 10m telescope.

The instrumentation has changed since 1984, thankfully! Today the main workhorse on the INT is the Wide Field Camera (WFC). This has 4 CCD detectors, each 2000x4000 pixels. The pixels are 13.5 μm on the side subtending 0.33" per pixels, so the field of view of the camera is 34 arcmin on the side. Note that there are gaps between the chips as can be seen on the figure on the next page

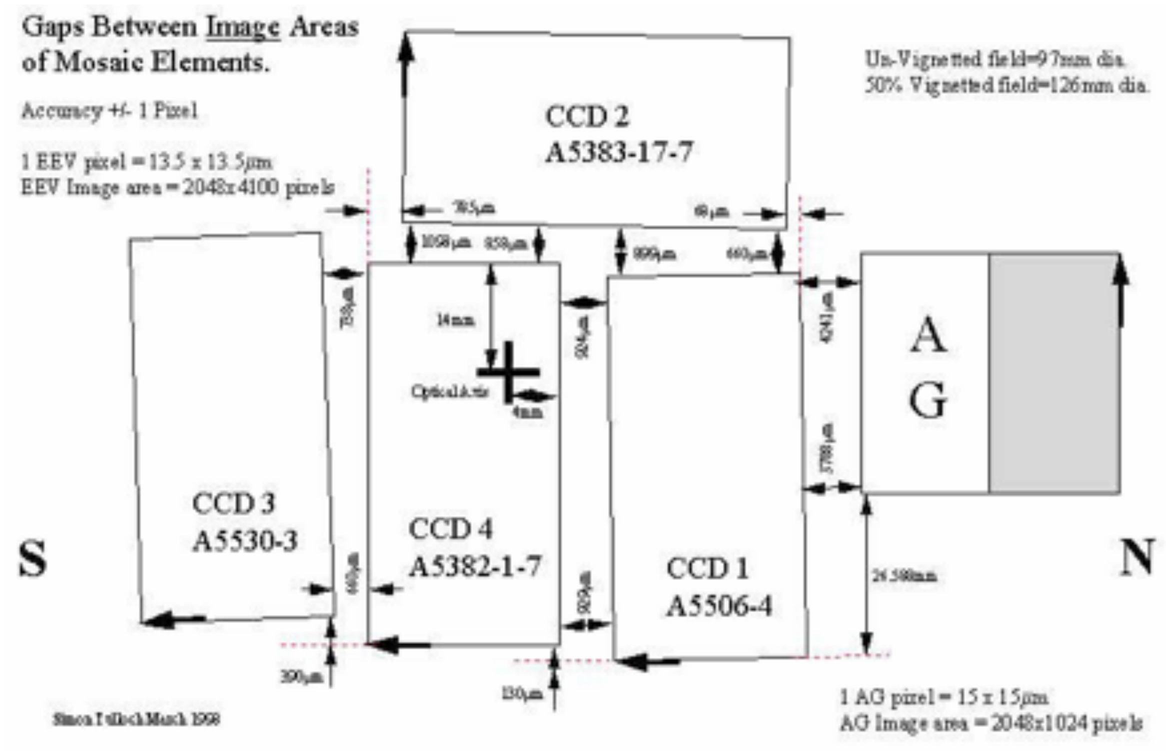

Figure 2: The physical layout of the WFC CCDs. Note the gaps and slight rotations. The part denoted by AG is the autoguider and is not of relevance for you. Credit: INT web pages.

(taken from the ING web pages). It is considerably easier to handle a single chip rather than try to combine a full mosaic so I prefer that your science case does not require mosaicing.

You can find more information on the WFC on the web pages for the camera.
You can also find information on the INT here (ING) and here (Wikipedia) and on the observatory.

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1. When is the object visible?

In order to determine when an object is visible you need to know its right ascension (Ra, "rechte klimming") and its declination (Dec). The visibility of an object depends on this, but also on the time of year and your location on the Earth.

I will shortly describe the programs we use to calculate the visibility of an object, but it is useful to have some feeling for this without having to fire up a program each time. For this it is best to focus on right ascension first - recall that at the time of spring equinox, around March 21 the sun has Ra=0. Of course we do not observe during the middle of the day - the middle of night is 12 hours later, so objects around Ra=12h will be optimally placed at this time.

The sun travels 30 deg, or 2 hours, per month. Our observing run is typically in the beginning of May, so a bit more than 1 month later, so the sun will be just a bit past Ra=2hr. This means that objects located near Ra=14hr will be particularly well suited for observations at that time.

The declination is of course also crucial - if the object is too far south it is not possible observe it. In general it is best to observe astronomical objects through as little atmosphere as possible. How high a particular object will be in the sky depends on the declination and the latitude of the observatory - an object with declination equal to the latitude of the observatory will pass approximately through zenith[1].

In practice we make use of pre-written programs to do our visibility calculations. There are a few of these available. The default for our course is the staralt program on the ING web site. But you might find it useful to have a list of few different ones:

- staralt - http://catserver.ing.iac.es/staralt/index.php. This is the main program used for observations with telescopes in the ING group but it can be used for other observatories as well.
- JSkycalc - http://www.dartmouth.edu/~physics/labs/skycalc/flyer.html. This is a graphical program that can provide a lot of useful information for your observing run. It is a modern version of probably the most widely used program for observing preparation, skycalc. There is an AstroBetter post discussing it in more details here.
- ESO provides a range of tools on their Calendars and Calculators web page.
- For those with a Mac iObserve is the Rolls Royce of observing planning - but it does cost real money (around €20) and is not needed for our observing run.

What filter(s) shall I choose?

The choice of filter depends on your scientific goals. If you require colours you need to have at least two different filters. If you want to target an emission or absorption line you might want to combine a broad and narrow filter centred on the emission/absorption feature of interest.

Keep in mind that the sensitivity of the CCD does vary with wavelength - choosing a filter that is located where the sensitivity drops will lead to an increase in the required exposure time.

The background emission from the sky will also affect your exposure time need. We will be observe when the moon is full - the period we refer to as "bright time". The moon shines from reflected sunlight and for that reason the night sky is blue in colour for precisely the same reason it is during the day. This means that the background is higher in the bluer filters - again a factor you need to consider.

Finally there is space for a limited number of filters (6) in the filter wheel of the instrument, and we need to specify our filter needs in advance. We therefore might need to make adjustments to the filter choice.

You can find a list of the possible filters at:

http://catserver.ing.iac.es/filter/list.php?instrument=WFC

How long shall I expose?

This is often the more challenging aspect of a proposal - you always want to integrate for long enough, but not much longer, and you must also make sure you do not over-expose your object.

[1] It says "approximately" here because latitude normally refers to geodetic latitude which is slightly different from the astronomical latitude.

To organise your thoughts on this you might find the following list useful:

1. How bright is your object? If it is variable take note of both the brightest and faintest magnitudes.
2. What filter(s) are you using? Remember to calculate exposure times in each filter separately.
3. How precise do your observations need to be? We usually quantify this in terms of the signal-to-noise ratio (SNR) - where a SNR of 10 means an accuracy of about 10%. If you need to detect variations at the 10% level you therefore need a much higher accuracy on your observations. How much more you need to estimate.
4. Is your object bright? If so make sure you do not expose so long that it becomes saturated.

To calculate the SNR and exposure times you need to make use of the exposure time calculator:

http://catserver.ing.iac.es/signal/

How many observations do you need and at what cadence?

This requires careful assessment - for some objects it does not really matter, for others the time of observations is crucial. An additional challenge is that we will have several observing programs to do and they all need to combine well.

If you look for brightness variations in your observing programme you need to think carefully about what time-scale these happen on and when you need to observe precisely. You also need to judge how many exposures you need to get a good enough result. You cannot ask for an arbitrary number because others also need the time to do their observations and a project that requires a lot of observations is also quite risky because the weather might cause problems.

Thus if you do have a time-critical observation it is a good idea to provide a minimal sampling needed and also a maximal sampling beyond which you do not gain much. That will make it easier to consolidate the observing programme.

In general you can assume that you can plan for a project that requires 1-2 hours of on-sky time. This time includes integration time, but also the time required to move the telescope and get ready for observations (5-10 minutes) as well as the read-out time of the CCD which is of the order of a minute.