3.4.2 Combination of switches

The following is a short list of the most used combinations of switches with an explanation of what the command does. All the commands below are actual commands used with PRISMS.

@tc @pd 0.25,0.2 @pn 27,8 @i C159Flowers.i
: This is the usual appearance of a mosaicing command. The `@tc` switch tells the program that it should attempt to focus in the default filter (as indicated by the config file) and use the ratios to calculate the exposure time for the other channels. `@pd` sets the normal increments the mount will move in azimuth and altitude. The size of the mosaic is given by the `@pn` switch; 27 images across and 8 rows high, thus a total of 216 images. The output is *C159Flowers.X.Y.v*.

@z 46907 @pd 0,0 @pn 0,1 @i Lbkg.v
: This command will take a single-shot image of all the filters available. It will not try to attempt to focus since the focus position is already set by the `@z` switch. The `@pd` switch has parameters $0, 0$ since the mount will not move, while `@pn` is set to $0, 1$ since there is one image taken on the first row. The image will be saved out as *Lbkg.v*. This command is a simpler form of the full mosaic command.

@c LMCB.0.0.v,bkgr
: The program will try to locate the file *LMCB.0.0.dat* associated with this .v file and read in the settings. Then it will effectively take a single-shot image using these settings and save out another file with the name *bkgr* appended: *LMCB.0.0.bkgr.v*.

@f 1 @z 39844 @pd 0,0 @pn 0,1 @i Stamp1.v
: This command will use filter number 1 at the focus position of 39844 to expose and save the image out as *Stamp1.v*. Since no integration time is given by a `@t` switch, the program will take an autoexposure.

@z 35151 @f 0,1,···,9 @t 100,100,···,100 @i Test.v
: This command will keep the focus fixed at 35151 and go through all 10 filters and expose the camera at 100ms each. This is good for tests. The ellipsis indicates missing filters and integration time. In the command line you **must** type out all filters and all integration times.

3.5 Focus

The idea behind auto-focussing in PRISMS is that the focus measure calculated in the ROI (see 3.3.1) should provide a single maximum peak and this peak should coincide with the best focused image received from the camera. However, most focus measured calculated from an image are unimodal only locally. Therefore, it is indicated first to try to move the focusser as close to the focus as possible and then use the auto-focussing routine to calculate the true position. Because of the local unimodality the focussing routine can find erroneous focus positions almost anywhere.

There are two main focussers: the telescope and the TL1 (T-cube, see 3.1). The default steps for the telescope focusser is 60 while for the TL1 is 600. Usually the TL1 settings for focussing increase by an order of a magnitude.

The algorithm employed by PRISMS to calculate the focus measure is called the 'energy of the gradient' and it is defined by:

$$\text{EoG} = \sum_x \sum_y (f_x^2 + f_y^2), \tag{3.1}$$

where

$$\begin{cases} f_x = f(x+1, y) - f(x, y) \\ f_y = f(x, y+1) - f(x, y) \end{cases} \tag{3.2}$$

This measure is updated periodically as new images are captured, and displayed in the image control section of the program (see 3.3.1).

When focussing, the program will keep track of the focus measure and it will stop if the following are both true at the same time: *(a)* there was a local peak, *(b)* after the local peak the focus measure dropped by a specified number of steps (see 3.1 to change the number of steps). The default number is 4. After the value of the focus measure has dropped, PRISMS will try to fit a gaussian to 5 points around the peak, including the peak itself, and will return the position of the peak of the fitted gaussian. This position is the fitted focus position. The fitted parameters are also displayed in the 'status window'. You may wish to check visually if the fitting routine was correct by displaying the image at a 1:1 ratio.

During a mosaic command we want to save as much time as possible so the auto-focussing is a bit more complex. First, the focus position backtracks a predetermined number of steps (usually 500) and tries to focus from there (**NB**: it is very important to be close to the focus when starting a mosaic). The focus measure is calculated at an exposure time predefined by the user (either config file or 3.3.1). If the focus could not be found after 20 steps, then the focus position backtracks to the initial position and tries to focus using auto-exposure. Again, if the focus was not found, it will use the position of the maximum focus measure as a last resort. It is very rare that a focus peak can't be found using an auto-focus exposure time. The fitted focus position of each image and row are stored and used as references when doing a mosaic, to help improve the speed of the process. The expected focusing time with a reduced exposure in a mosaic is ∼4.5sec.

Also, during a mosaic if the focus measures decreases straight away from the focus measure of the initial position, the focus will backtrack a lot more steps so that it ensures it will find a peak. This is possibly dangerous as for certain configurations of the target PRISMS will sometimes send the focusser to position 0 and will fail to focus. You must be careful when this happens. Most of the times, however, PRISMS will try to refocus using the optimal exposure time which in almost all the cases will find a focus.

3.6 Cos θ

We are using the telescope in an Altazimuth mount configuration. Essentially, when mosaicing we are mapping the scene onto a hæmisphere and so we have a singularity of the coordinate system at 90°. Therefore we are in practice mosaicking a slice of the hæmisphere whose width at 0° is unaffected, but is shrunk as the telescope moves in altitude by a factor, ultimately reaching at *one* image at the singularity point. The size of the mosaic's width changes with altitude according to the formula

$$W = \lfloor W_i \cos(\theta) \rfloor$$

where W is the current width of the mosaic, W_i is the initial width and θ is the altitude angle in radians. W_i is calculated as $\Delta Azi \times d$, where ΔAzi is the increment in the azimuth at 0° as