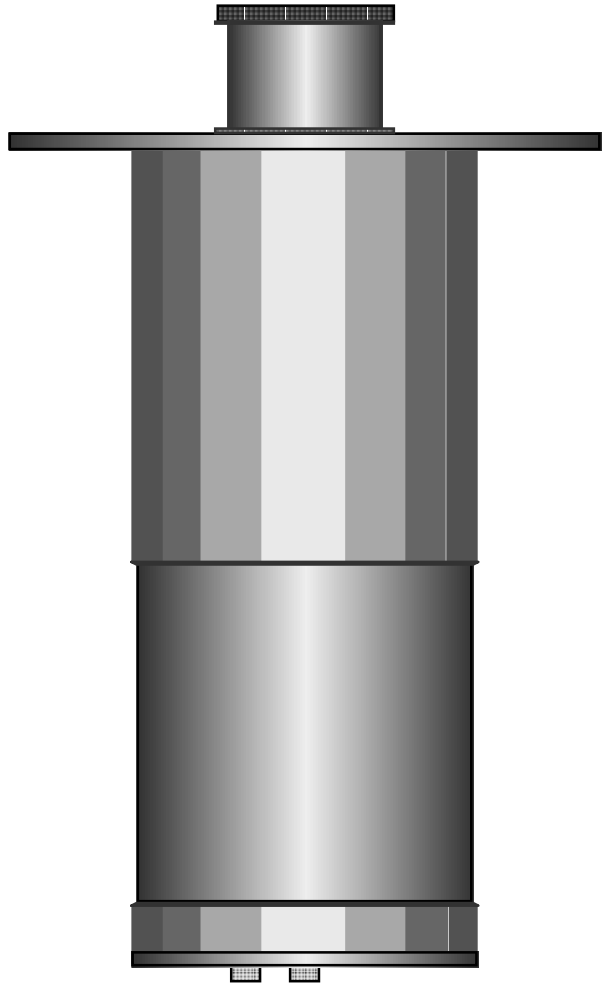
MAGIC

Observer's Guide

by T. M. Herbst



Guidelines for using Blue and Black MAGIC
on the Calar Alto 3.5 m and 2.2 m telescopes

Maual Revision 1.4 - 18. July 1995 Peter Bizenberger

Table of Contents

Foreword 3
Introduction 4
Infrared Detectors 4
Noise Sources 5
  Sky Background 5
  Read Noise 5
  Dark Current 5
S/N Considerations 6
Readout Techniques 7
  Reset–Read 8
  Reset–Read–Read 8
  Multiple End Point Sampling 8
  Sample Up the Ramp 9
  Subarray 9
Calibration Strategy for Direct Imaging 9
Sky Subtraction 11
  Point Sources–Moving Sky 11
  Extended Sources 11
Flat Fielding 14
  Sky Flats 14
  Dome Flats 14
  Flat Fielding Procedure 15
Linearity 15
Grism Spectroscopy 16
  Observing with the Grisms 17
A Typical Observing Sequence 18
Start-up Procedure 19
Checking Star Counts 19
Aligning MAGIC on the Telescope 20
  Checking the Alignment 22
  Adjusting the Alignment 22
  Tipping the camera mount. 23
Troubleshooting 24
Filters 25
Object List 26
Macro 27
Further Reading 28
Appendix A: Technical Characteristics and Astronomical Performance 29
Appendix B: Macro Commands 31

MAGIC

Observer's Guide

by T. M. Herbst

2 May 1994

Foreword

This manual provides observing guidelines for MAGIC, the **M**PI für **A**stronomie **G**eneral–Purpose **I**nfrared **C**amera. It is not a comprehensive discussion of the techniques and tools of infrared astronomy. Rather, it provides a brief introduction to the problems associated with observing in the infrared and suggests general strategies for minimizing these difficulties. Separate documents contain detailed instructions for operating MAGIC itself.

The MAGIC team wants your observations to be successful. Please contact Peter Bizenberger (Tel. +49 6221 528311, FAX +49 6221 528246, e-mail: biz@mpia-hd.mpg.de) if you have any questions or suggestions.

THE MAGIC TEAM

Name	Speciality
Steve Beckwith	Science, Hardware
Christoph Birk	Software, Hardware
Peter Bizenberger	Hardware, Observer Support, Logistics
Tom Herbst	Optics, Spectroscopy, Science, Manuals
Stefan Hippler	Network Software, Sun Computer
Mark McCaughrean	Imaging, IRAF, Hardware, Science
Filippo Mannucci	Deep Imaging, Performance Spec's.
Grzegorz Pojmanski	Graphical User Interface, Software
Jürgen Wolf	Project Manager, Detector Spec's.

Introduction

The main challenge of infrared astronomy arises from the enormously higher sky background levels in the IR compared with visible wavelengths, for example. The sky brightness in the V band is 22 mag / arcsec^2 at a typical site such as Calar Alto. At 2 μm, the sky brightness is approximately 13 mag / arcsec^2 (measured with MAGIC on the 3.5 meter telescope). One normally wants to observe objects that are 8–9 magnitudes fainter than the sky level in the infrared, a challenge that visible wavelength astronomers rarely confront.

Infrared Detectors

Infrared arrays differ from visible wavelength CCD's in requiring special semiconductors with a smaller energy difference between the valence and conduction bands. Typical materials include indium antimonide (InSb), platinum silicide (PtSi), and mercury cadmium telluride (HgCdTe). MAGIC's detector is a HgCdTe device.
The figure below contains a schematic drawing of the Rockwell NICMOS3 infrared array in MAGIC.

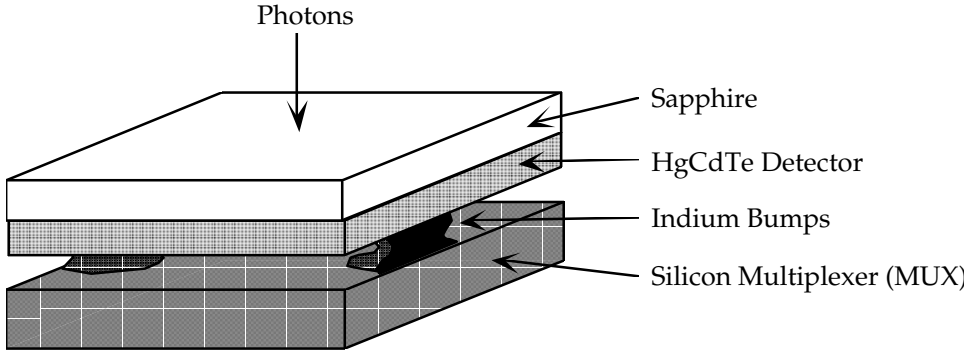


Figure 1

Photoelectrons are collected in the detector material and read out using a multiplexer. Because silicon multiplexer technology is much more mature, HgCdTe and InSb arrays are *hybridized*. This means that the detector material is cold welded to a silicon multiplexer using a series of small indium bumps. The actual HgCdTe detector material is grown on a sapphire substrate for mechanical strength. This hybrid arrangement has the benefit of lower crosstalk and less blooming and streaking compared with visible wavelength CCD's. Another significant advantage of the hybrid is that it permits *non–destructive readouts* of the detector, in which the voltage on the pixels can be measured without affecting charge collection. The main disadvantage is that the thermal mismatch between silicon and sapphire limits the size of these devices to approximately 10mm square.

Noise Sources

The same noise sources that plague visible wavelength CCD's affect infrared detectors, although their relative importance can be quite different. The primary sources of noise in infrared observations are sky background, read noise, and dark current.

Sky Background

At wavelengths longward of 2.3 μm, thermal emission from the atmosphere and telescope produces significant background. Shortward of 2.3 μm, the sky signal is dominated by airglow emission from molecules, primarily OH and O_2. This background can vary significantly, both spatially and temporally, (see Further Reading, below). Accurate photometry in the infrared means careful measurement of the sky level, and sky variations constrain integration times and general observing strategy.

Sky background introduces noise in two ways: (1) Imperfect subtraction of a varying sky level produces scatter in the photometry, and (2) Even in constant background conditions, there is shot noise associated with the high background photon flux. The latter noise is proportional to the square root of the number of background photons.

Read Noise

Each readout of the detector array has an associated noise level known as the read noise. This noise is a fixed quantity *per readout*, but it can be reduced with special sampling techniques to lower the effective read noise *per integration* (see below).

Current (1993) detector and multiplexer technologies have read noises of approximately 30 electrons per readout. Special sampling techniques can reduce this noise by a factor of approximately three. The next generation of arrays should produce less than 10 e^- read noise per readout.

Dark Current

Dark current in an infrared detector results from the same process as in visible wavelength CCD's: thermal oscillations excite valence electrons into the conduction band, producing carriers in the absence of photon absorption. Since the band gap is smaller in an infrared sensitive semiconductor, IR arrays must be cooled to lower temperatures to suppress this dark current. MAGIC's detector and optics are cooled to approximately 77K with liquid nitrogen. The combination of LN_2 cooling, smaller pixels, and improved detector materials means that MAGIC's dark current is negligible in almost all observing circumstances (measured at approximately 0.5 e^- / sec).

S/N Considerations

The character of the noise sources described above gives a signal to noise ratio (S/N):

$$S/N = \frac{G \cdot F_0 \cdot t}{\sqrt{N_{pix} \cdot \left((G \cdot F_{tot} + I_d) \cdot t + RN^2 \right)}} \qquad (1)$$

where t is the integration time (sec)

G is the photometric gain (e^- / photon)

F_o is the *total* source flux (photons / second) from the target object

N_{pix} is the number of pixels summed across the object

F_{tot} is the total flux (photons / sec) *per pixel* from the object, sky, telescope, etc.

I_d is the dark current (e^-/ sec)

RN is the read noise (e^-)

In most instances, the target object is fainter than the sky background. For a typical exposure with MAGIC using double–correlated sampling (see below), the read noise N_r is approximately 50 e^-, and the dark current is 0.5 t e^-. The photon noise associated with the sky background increases as the square root of time. Therefore, the signal to noise ratio increases approximately linearly with time until sufficient background photons have been collected to dominate the noise sources. This occurs when

$$G \cdot F_{tot} \cdot t \geq N_r^2$$

i.e. when the background signal is more than the square of the read noise, or 2500 e^-. With MAGIC, the conversion factor between electrons and Analog to Digital Counts (ADC – one ADC is the minimum signal unit recorded by the computer) in the image is 9.7 e^-/ ADC. Therefore, any integration with less than approximately 250 sky counts is read noise limited , and the signal to noise ratio increases linearly with time. Longer exposures are background limited, and the signal to noise ratio increases only as the square root of time. The following figure shows this schematically.

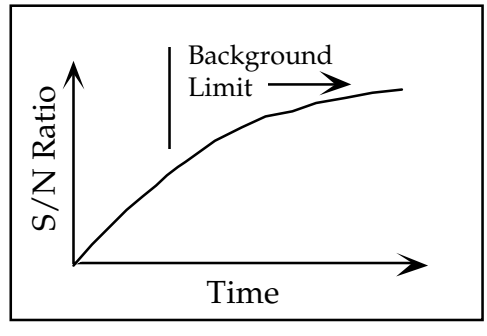


Figure 2

Integrating for much longer than the time needed to reach the background limit does not provide any advantage to the observer, since a series of independent exposures will also increase the S/N ratio as $\sqrt{t}$. **In fact, the variability of the sky level and other factors make it advantageous to end an exposure when the background limit is reached.** For broadband images with MAGIC, this usually requires only a few seconds.

The MAGIC software does not require you to set up and take a large number of short exposures in order to observe near the background limit. There are options for automatically taking a series of images or adding a number of frames to a single file. There is a tradeoff between adequately sampling any sky variations and coming back from the observatory with tens of thousands of images. You should judge the best compromise based on the sky conditions, the required photometric accuracy, and your ability to record, transport, and reduce the resulting data. In our experience, exposure sequences lasting a minute or two work well (for example, fifteen frames of 4 seconds added together and saved to a single file). Single, longer duration exposures are fine for lower background observations with the narrow band filters or grisms.

We have ignored the photon shot noise associated with the target source in the discussion above, since the sky is usually considerably brighter than the object. In those lucky instances when the target is considerably brighter than the sky, the observer can achieve good signal to noise ratio very quickly, and the observing efficiency is then limited by telescope moves, exposure setup, etc.

Readout Techniques

The figure below is a schematic representation of the voltage on an individual pixel as a function of time. At the beginning of an exposure the voltage is set to a predetermined value by a *reset*. When the reset switch is opened, the voltage will jump to a variable new level* (the *pedestal*) and then increases linearly with time as charge from photoelectrons and dark current accumulates in the detector. This process continues until the detector is reset to the original level at the end of the integration. The linear behaviour of most modern detectors spans the range from zero charge to over 90% of the total capacity, which for MAGIC is approximately 300,000 electrons (30,000 counts).

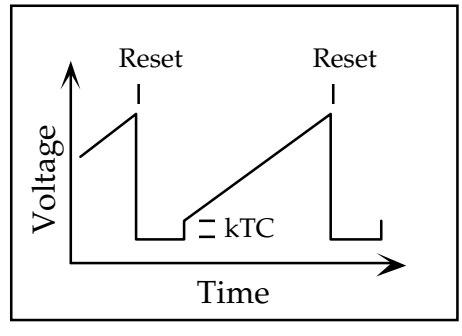


Figure 3

* The variability is caused by a quantum noise source called kTC noise, the thermally induced fluctuations of voltage on a capacitance C at temperature T.

MAGIC supports a number of detector readout modes suitable for various observing situations. These modes appear under the <Readout> menu and can be invoked with the **`ctype`** instruction from the command line interface and from macro files.

Reset–Read

(ctype rr)

This is the simplest readout scheme. The pixels are reset and read out once at the end of the integration. This does not remove the variable pedestal level (kTC noise) and any initial offsets which can vary from pixel to pixel. We do not recommend using this mode for observation. Its main usefulness is in checking the signal level for saturation. **Saturation occurs at 45,000 counts.** (The previous page stated 30,000, but there is a 12,000 count offset in the software)

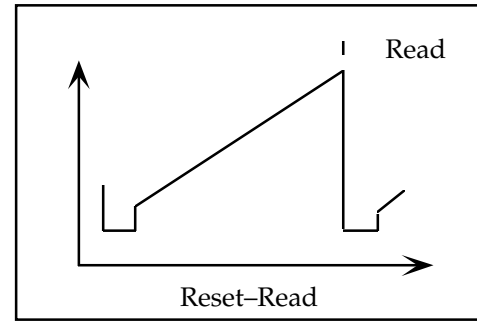


Figure 4

Reset–Read–Read

(ctype rrr)

Also known as Double–Correlated Sampling, this is the most commonly used mode for general observing. The array is read immediately after the initial reset and before the final reset at the end of the integration. This eliminates the kTC noise and other offsets, but increases the read noise by Ã2 because the noise from two readouts goes into a single image. We recommend this readout mode, particularly for broadband imaging where you reach the background limit quickly (and can thus accept the higher read noise). **Saturation occurs at 30,000 counts.** Min. integration time ≈ 60 msec.

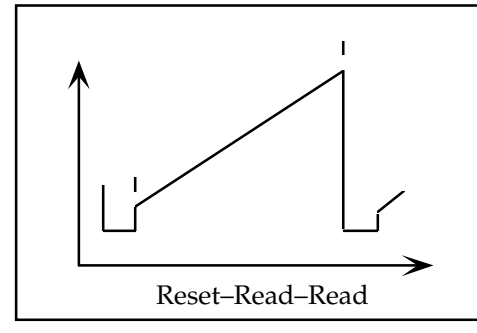


Figure 5

Multiple End Point Sampling

(ctype multi A B)

This variant of Double–Correlated Sampling is also known as Fowler sampling (see Fowler and Gatley 1990). The array is read multiple times after the initial reset and before the final reset (the values A and B tell MAGIC how many reads to perform). This scheme can reduce the read noise substantially, theoretically by a factor ÃN. In practice, however, amplifier glow and other effects limit the reduction to a factor of approximately three with MAGIC. We recommended this mode in low background situations such as grism spectroscopy. **Saturation occurs at 30,000 counts.**

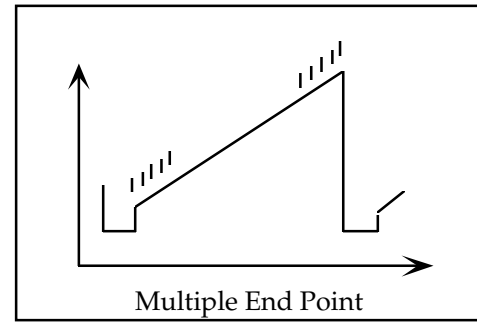


Figure 6

Sample Up the Ramp

(ctype ramp N; ctype speckle N)

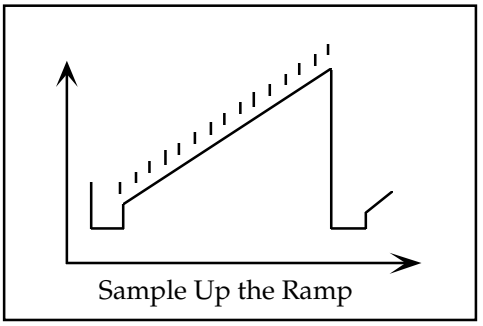


Figure 7

This readout scheme also reduces the effective read noise, since the pixel voltage is sampled N times at equal intervals during the integration. The total signal comes from a linear fit through the measurements (ctype ramp) or from saving the differences between adjacent reads (ctype speckle). The latter is used for speckle interferometry since the observer can save these adjacent differences as separate frames, each of which is a rapid exposure on the sky. Currently, MAGIC can take up to 256 frames at up to 20 Hz in this fashion. Warning: Be careful not to saturate the **total** signal in this mode. This can happen easily when observing lunar occultations, for example. You may have to settle for a shorter sequence. **Saturation occurs at 30,000 counts total.**

Subarray

This readout scheme reads a square box of variable size. The readout speed can be increased according the size of the subframe (see table below).This mode is well-suited to occultations.
The actual readout technique is Reset Read Read. The size of the subframe must be an even number and the x position of the centre has to be an odd number. In addition the subarray has to be located entirely in one quadrant of the detector.
For efficiency we recommend that the box size be a power of 2 (e.g. 4,8,16, ...).

Dimension of box size	$T_{Integration}$ for 100 frames /msec	T_{Cycle} /msec	$T_{Integration}$ for 2048 frames /msec	T_{Cycle} /msec	T_{Total} /sec
8x8	4	10	4	10	21
16x16	6	16	8	19	38
32x32	10	28	25*		
64x64	21	61			

* for 1024 frames

Calibration Strategy for Direct Imaging

MAGIC calibration procedures, such as measuring the pixel to pixel gain variations using dome or sky flats, are similar to those used for visible wavelength CCD's. There are differences, however. For example, it is critically important to have frequent and accurate sky level measurements, since the sky is bright and variable at infrared wavelengths. On

the other hand, the relatively short exposures, high backgrounds, and frequent sky measurements make dark current calibration unnecessary.

The measured detector voltage contains several contributions besides the source flux we wish to observe. We can write this voltage V_0 as follows:

$$V_O \approx \left[G(x,y)\cdot\left(F_O + F_b\right) + I_d\right]\cdot t \qquad (2)$$

where (as before) t is the integration time

G(x,y) is the photometric gain measured in electrons/photon at pixel location (x,y)

F_O is the number of photons/sec from the target object

F_b is the number of photons/sec from the sky background

I_d is the dark current in electrons/sec

Here we explicitly recognize that the photometric gain can vary from pixel to pixel. We isolate the source flux by taking a sky frame whose signal V_S will be:

$$V_S \approx \left[G(x,y)\cdot F_b + I_d\right]\cdot t$$
$$V_O - V_S = G(x,y)\cdot F_O \qquad (3)$$

The difference between these voltages eliminates all undesired effects except the pixel to pixel gain variations. These can be calibrated with a flat field image (discussed fully below). The difference in signal between exposures of the dome wall with the lights on and off is:

$$FF_{on} \approx G(x,y)\cdot Q\cdot t' + I_d\cdot t'$$
$$FF_{off} \approx I_d\cdot t'$$
$$FF_{on} - FF_{off} = G(x,y)\cdot Q\cdot t' \qquad (4)$$

This is exactly the gain factor (times the constant Qt') remaining in equation (3) above. Division of equation (3) by equation (4) isolates the target object signal. Applying the same flat field to images of a known reference star eliminates Qt', giving the absolute flux calibration. As with CCD's, careful photometry requires frequent calibrator star measurements at a range of zenith angles.

The flowchart on the next page shows the calibration steps discussed above.

Warning: Since the sky background can be significantly higher than the source flux, it is important to have an accurate measure of F_b. This means taking sky frames close in time to the object frames. Although it reduces observing efficiency, **do not skimp on sky frames**. You will regret it. There are macros in the data system to take frequent sky exposures with little impact on efficiency (see Moving Sky, below).

Sky Subtraction

Point Sources–Moving Sky

When the observing targets are pointlike or small, most of the array is, in fact, measuring the sky background level. A simple strategy to take advantage of this information is shown schematically in figure 9. Offsetting the telescope between exposures produces a sequence in which a subsection of the array contains the target object in one exposure and sky measurements in all the others. A median average of these sky frames will eliminate the pointlike sources (*i.e.* an image in which each pixel is replaced by the median of values at that location in all the sky frames) . Taking the median of, say, four neighbouring frames will give a sky level that is well–correlated temporally and spatially with that in the target exposure. This so–called "moving sky" frame works extremely well with virtually no penalty in observing time, since you should already be moving the telescope slightly between frames to account for bad pixels. **You must move the telescope by at least twice the size of the largest observing target for this technique to be effective.**

Extended Sources

When the observing target is extended over a significant portion of the detector, the moving median will be contaminated by source flux and will not reflect the current sky level. In these circumstances, the observer **must** offset the telescope to a relatively source–free area to measure the sky. A typical sequence may be Object–Sky–Sky–Object–Object–Sky–Sky... The atmospheric conditions are the major factor in deciding how frequently to measure the sky level. Note also that most "empty" fields contain numerous stars, particularly given the large field and high sensitivity of MAGIC. You should offset the telescope between sky exposures and form the median as before to eliminate point sources. The positive aspect of taking frequent off–source exposures is that it gives you an opportunity to monitor the atmospheric transparency, seeing, and focus using a star in the sky field.

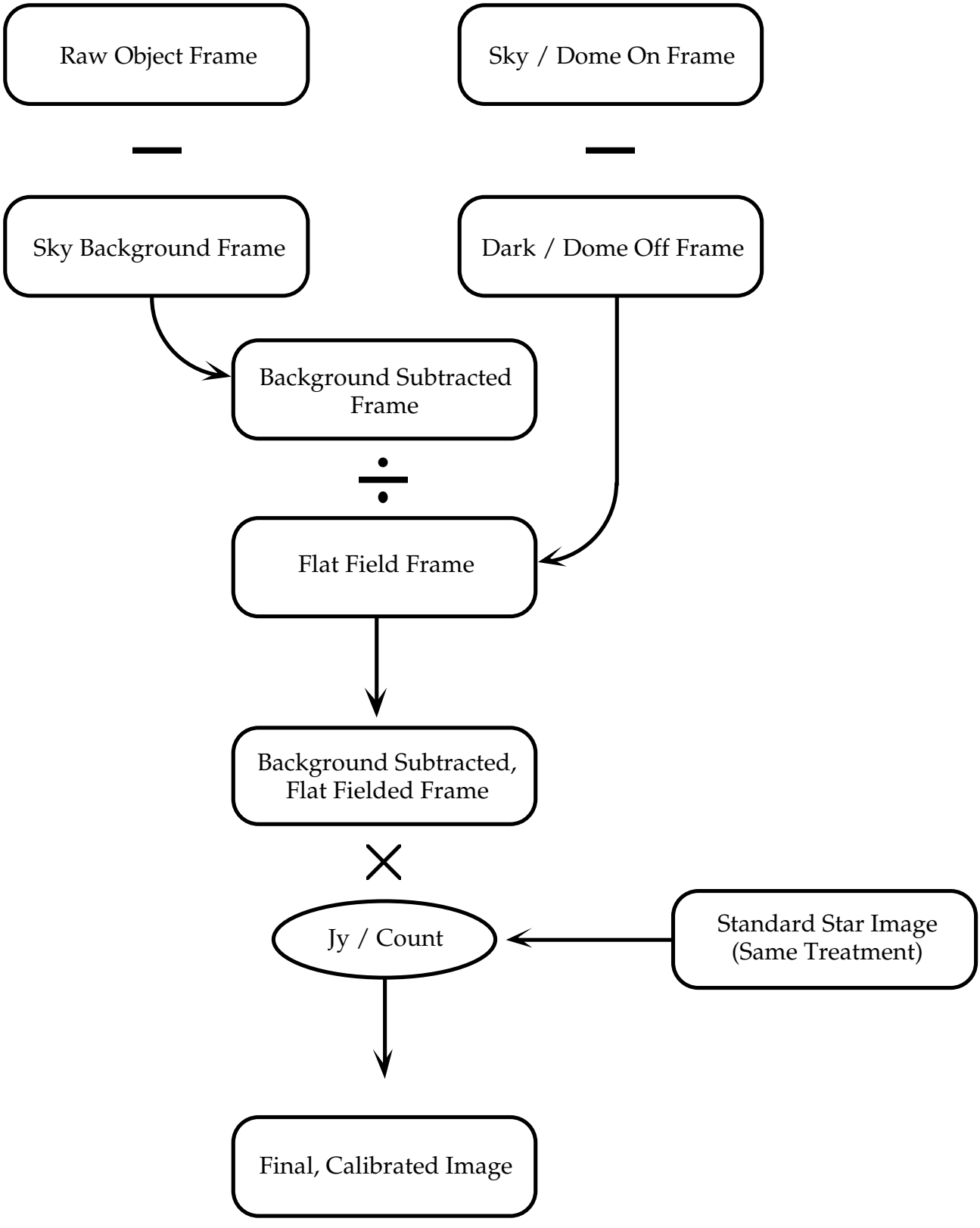


Figure 8 - Infrared Image Calibration Flowchart

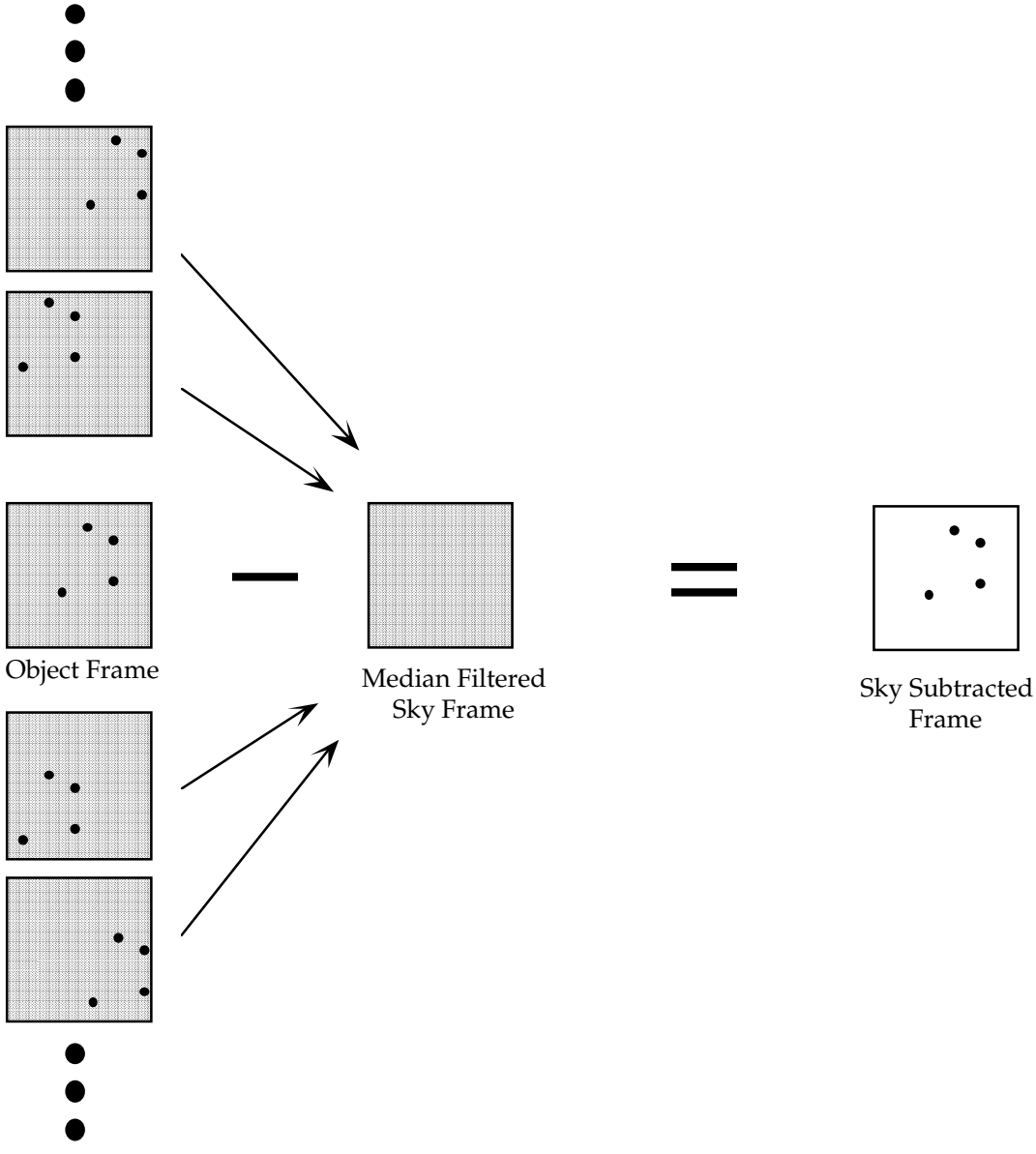


Figure 9 – Schematic Representation of the Moving Sky Technique

Flat Fielding

The *flat field image* provides a means of removing pixel to pixel gain variations in the array. There are several different techniques for producing the flat field, but they all share the goal of exposing the detector to uniform illumination. The image values in the resulting frame will be proportional to the pixel gains. Division of the object frames by the flat field will eliminate these variations.

Sky Flats

Source–free sky exposures should contain only dark current and sky background flux, which is uniform over MAGIC's field of view. Subtracting an exposure of the same duration taken with the camera internally blanked off (a *dark* frame) will, in principle, yield an image of uniform illumination, in other words a flat field. In practice, however, the sky is almost never source–free, so we recommend the median averaging procedure (discussed above) to remove the stars. This type of flat field is like the moving sky frame, in that it comes without additional observing overhead – the same exposures can be used for object, sky, and flat. However, **do not forget to take dark frames of the same duration** to subtract dark current and other offsets if you use this type of flat field.

Two other caveats deserve mention. First, the flat field is divided into **every** exposure. **Make sure the sky flat has sufficient signal to minimize additional noise**. For this reason, sky flats are generally not practical for narrow band imaging. Second, the sky background may not be uniform **spectrally**. Sky flats are not recommended for grism spectra, since the bright emission lines will mimic higher detector gain. In the K band where thermal emission increases dramatically at the long wavelength end, the sky flat may reflect the gain variations at an effective wavelength quite different from the peak emission of your science objects. Proper calibration with a standard star of known spectral type should eliminate any difficulty, but extra care must be taken for high accuracy photometry.

Dome Flats

Another way of obtaining uniform detector illumination is to point the telescope at a bright, blank surface. This produces a *dome flat.* At the 2.2 and 3.5 meter telescopes on Calar Alto, any bland part of the dome illuminated by lights will work. You will have to adjust the location, intensity, and direction of the lamps to get adequate signal levels without saturating the exposures. We have found that short integration times work well (*i.e.* 100 frames of 0.1 second averaged to a single file for K). Also check that no uneven shadows are cast on the part of the dome being measured.

Dark current and offsets appear in the dome flats as well, so we recommend taking an exposure of equal duration with the dome lights off. This also subtracts thermal emission of the dome in the K band and thus gives a flat field with the known intrinsic colour temperature of the lights.

Flat Fielding Procedure

The following are some general guidelines which will be appropriate for most observers:

1. **Take flat fields in every camera and telescope observing configuration you use.** This is extremely important. A K band flat will **not** suffice for J band observations, etc. Until we better understand the systematic characteristics of MAGIC, we also recommend taking flats in all readout modes you use (*i.e.* separate flats for Reset–Read–Read, Sample–Up–The–Ramp, Sub–arrays, *etc.*).

2. We have not observed variations in the flat field response within a single observing night. At this time, we recommend taking flats once per night. This can be done at any time – we routinely flatfield just before or just after sunset. In good weather, the flat fielding measurements are often delayed until the end of the night.

3. We have not yet had enough photometric weather to cross check the sky and dome flat procedures. We therefore recommend taking dome flats as insurance, even if you plan to use sky flats. Please keep us informed of how well all these techniques work out.

Linearity

The calibration procedures discussed above assume that the voltage on the detector is linearly proportional to the incident flux. We have measured this relationship for the detector in MAGIC. Figure 10 shows the number of counts per photon as a function of signal counts. The curve is normalized to 1 at zero counts. The deviation from linearity is less than 4 % at 30,000 counts. Normal reset–read–read exposures should not exceed 25,000 counts.*

Note that the linearity plot uses the *median* counts for the 65,536 detectors. Some pixels are more nonlinear and others less. Observers who need accurate photometry will want to correct all their exposures for nonlinearity **before** proceeding with the standard data reduction. We recommend using a second or third order polynomial fit to each detector's response. Speak to a MAGIC team member about getting the latest coefficients (these are essentially images whose individual pixel values are the response coefficients).

* This number can be lower for extremely bright objects (those which produce >20,000 counts in less than 0.5 second). This is due to charge accumulating in the detector between the reset and the first read (see the Readout Techniques section). Therefore, the difference between the first and second reads can be less than 25,000 with the **total** counts exceeding the linear range. In the extreme case, the detector saturates between the reset and the first read, and continues saturated until the second read. This produces almost zero total counts in reset–read–read mode. If you are in doubt, take a reset–read frame of the same duration and verify that the total counts are well below 45,000.

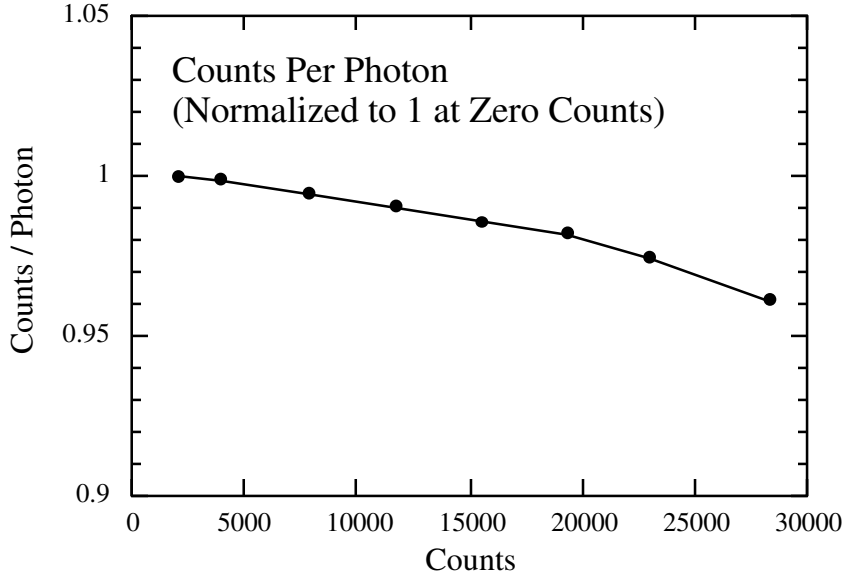


Figure 10

Grism Spectroscopy

MAGIC has a spectroscopy mode which uses one of two direct–ruled ZnSe grisms in combination with the high resolution optics to give a double sampled spectral resolution ($\lambda/\Delta\lambda$) of 370 or 185 (Herbst and Rayner 1993 – appended to this manual). One grism covers the entire K band in second order and the entire J band in fourth order. The second grism spans the H band in second order.
The spectral resolution is defined by the focal plane slits, which are two and four pixels wide for R=370 and R=185 respectively.
Both the grisms and the focal plane slits are on motorized wheels, permitting the observer to switch rapidly (~30 seconds) between resolutions and between direct imaging and spectroscopy modes.

In additon there is a resin replica grism available. This device gives a spectral resolution of R=260 or R=130 for the two or four pixels wide slits respectivly. This resolution means that the entire H and K bands can fit on the detector simultaneously in first order. J band measurements use second order. The replica grism can also be used with the Spaltspinne for multi–object infrared spectroscopy. Contact Tom Herbst for more details.

Spectroscopic observations with MAGIC are quite similar to direct imaging measurements in most respects. For example, the observer must take sky and flat field frames to remove background and pixel to pixel gain variations. On the other hand, acquiring good spectra with MAGIC requires extra care and attention to such things as persistence effects and telescope drift. The following paragraphs explain how to use MAGIC in spectroscopy mode.

NOTE ! Spectroscopy is only available with high-resolution optics except under special circumstances (discuss with P. Bizenberger).
It is not possible to change grisms during the night!

Observing with the Grisms

The easiest method for placing the target object in the slit is to take a sequence of direct images and use the telescope guide paddle or the user interface to place the object at the correct location. The slits in MAGIC are oriented along the y direction of the detector array (north–south if the Cassegrain flange rotator is at zero degrees). You can find the slit location in a ~5 second sky exposure with the slit and K filter. The slit wheel position is repeatable to approximately one pixel. We recommend that you check the slit position regularly, particularly in the higher resolution (narrower slit) configuration. Image persistence can be troublesome under low background conditions such as spectroscopy. To avoid problems, place bright objects in the correct detector *column* then move the source up or down the slit *after* inserting the slit and grism.

Exposures can be read noise limited at these spectral resolutions. To maximize observing efficiency, aim for at least 5000 electrons or 500 source counts per pixel in each exposure. As with direct imaging, there will be a tradeoff between fewer long exposures (sky variations and telescope drift) and many short ones (unwieldy number of frames).

Sky frames are important to remove airglow lines and thermal emission in the K band. For pointlike sources, the moving sky technique works well (see previous section). The displacements between consecutive frames must be along the slit direction, of course. For extended objects, move to a nearby blank sky location. Depending on how well the telescope offsets and returns, you may have to recenter the object in the slit. The autoguider can be a great help for these observations.

We recommend dome flats for calibrating the pixel to pixel gain variations, since only the longest sky exposures will have sufficient signal. The mounting flange contains an argon discharge lamp for wavelength calibration. In practice this lamp is rarely needed, since most frames will contain bright airglow lines whose wavelengths are well known (see Origlia and Oliva 1992).

The infrared spectral bandpasses contain numerous telluric absorption features. These can be removed by dividing each spectrum by that of a calibrator star. Consult a list of spectroscopic standards to determine the best spectral type for your program. All spectroscopic data reduction packages offer routines for interpolating across calibrator star absorption features to prevent artifact emission lines in the final spectrum. Also, dividing by a stellar spectrum introduces a spurious sloping baseline. This can be removed by subsequent multiplication by a blackbody of the same effective temperature as the calibrator.

In our experience, the standard astronomical data reduction packages such as IRAF or MIDAS contain all the tools necessary for extracting useful spectra from MAGIC frames. The documentation for these programs also contains useful information on difficulties associated with two dimensional spectroscopy, such as the extraction of tilted spectra and the removal of airglow lines.

A Typical Observing Sequence

First time users may appreciate an example of how a typical night of observing may proceed. The following (fictional) chronology assumes normal imaging operation at one of the Calar Alto telescopes.

TIME	EVENT
20:00	It is summer, so there is still approximately an hour until sunset. You arrive at the dome early to check the camera and to measure flat fields.
20:10	The MAGIC software is started and everything functions. You create a directory for the night's data files then move the telescope to the flat field position. Don't forget to take lamp–off exposures and to check for saturation in the flats. Take flat field images for all anticipated filters and readout schemes.
20:45	The sun is going down, so you can open the dome to cool things off and look for a standard star.
21:00	You select a standard star near the zenith. Focus the telescope for best image quality and when it is dark , take some photometric calibration images. Check the star counts (see below) to verify proper camera setup and good sky conditions. Some people find it easier to focus with many objects in the field, so you may want to use a globular cluster first. Look in the Astronomical Almanac.
21:20	The calibrations are complete and you begin observing your first program object. You move the telescope between subsequent exposures to account for bad pixels. The neighbouring frames can be used for the sky background and flat field, provided that your objects are point–like. Note that you need high sky levels to use the median averaged frame as a flat field.
22:00	Your first object is complete and you decide to observe a standard star at similar airmass. You will follow this star as it sets in order to get the extinction correction.
22:10 – 5:00	You continue observing program objects and standards. Scattered sunlight is much less problematic at longer wavelengths, so you can observe much later than at visible wavelengths. Remember to monitor the focus, particularly if you are observing extended objects.
5:40	The sky is finally too bright to do meaningful observations (the detector saturates on the background in very short integrations). You decide to finish up with a last standard star. Checking the observing log, you notice that you observed one object in a filter for which there is no flat field image. You take the final flat and shut down the camera software.
6:00	The telescope is parked, the dome is closed, and you have filled out the log sheet for the evening. You start a backup of the night's data onto a DAT tape, switch off the camera electronics, and head down to the hotel for breakfast and sleep.

Start-up Procedure

1. Switch on all three electronic boxes (two on the telescope, one in the control room).

2. Switch on the telescope. There is a separate manual for this procedure.
   At the 3.5m telescope, the offset system must be in Δalpha, Δdelta!

2. If you are at the 3.5m telescop, start the DACS program *HEL NICA35/*
   Wait for the prompt and follow the instructions (i.e. type *SETUP*). If there are any problems, logout from the Magic account and try again to start the DACS program.

3. Login as *magic22* at the 2.2m telescope or *magic35* at the 3.5m telescope.
   Password: _____ (the current password will given to you by the night assistant and will also pinned up in the control room)

4. Call up the GUI by typing *MAGIC* in the openwindow system.
   You should check that the filter wheels are really rotating and that they stop again.

NOTE: Take care that you use the correct set-up.

Checking Star Counts

We recommend checking the signal from a standard star at the beginning of each night's observing. This not only verifies that the camera is mounted, aligned, and operating properly, but also gives you some indication of the sky conditions. The procedure is quite simple:

1. Take a broad band exposure of a standard star of known brightness, for instance a K image of one of the objects listed in Elias *et al.* (appended to this manual).

2. Measure the total counts on the star using the image viewer tools. Make sure the radius is set large enough to get all the starlight. Also measure the sky counts in a nearby region of the same size, or preferably in the same region in a subsequent frame.

3. Calculate the Counts for Zero Magnitude (CFZM) per second according to the formula:

$$\mathrm{CFZM} = (\mathrm{src} - \mathrm{sky}) \cdot 10^{[0.4 \cdot \mathrm{mag}]}$$

   where src and sky refer to the counts *per second* on the star and sky, respectively. The value mag is the magnitude of the standard in the wavelength band being used. This calculation tells you how many counts that star would have produced if it were a zero magnitude object with a 1 second exposure.

4. Compare the CFZM with the table below. If you get a lower value which cannot be explained by poor sky conditions, there may be an alignment or setup problem. Call the night assistant or other qualified person to check that everything is working. You can check the alignment yourself. The procedure is described in the next section.

Telescope, Camera Config	arsec per pixel	J $10^8 s^{-1}$	H $10^8 s^{-1}$	K $10^8 s^{-1}$	K′ $10^8 s^{-1}$
3.5m f/10 Wide Field Optics	0.81	8.17			5.11
3.5m f/10 High Res. Optics	0.33				
3.5m f/45 Wide Field Optics	0.18				
3.5m f/45 High Res. Optics	0.07				
2.2m f/8 Wide Field Optics	1.6				
2.2m f/8 High Res. Optics	0.67				

Table 1 – Counts for Zero Magnitude for Various Configurations*

*Limited measurements at this time. Please contact your MAGIC support person for updates

Aligning MAGIC on the Telescope

NOTE: MAGIC should be aligned properly when you arrive at the telescope. However, you should check at the beginning of every telescope run to be sure, and you may choose to align it yourself if it is out of adjustment.

MAGIC must be aligned on the telescope so that an image of the telescope *pupil* falls on an internal cold stop, called the Lyot Stop. The entrance pupil of the telescope is the primary mirror, an image of which is formed by the secondary mirror at a location a few centimeters beyond the secondary. For the purposes of alignment, we can consider the pupil to be the secondary mirror.

The collimator lens within MAGIC forms the image of the pupil/secondary at the location of the Lyot stop. This stop is a small hole mounted on a motorized wheel between the two filter wheels. If MAGIC is not properly aligned, the pupil image does not fall exactly on the Lyot stop and light is lost. By slightly altering the mounting angle of the camera (or perhaps rotating the Lyot stop wheel a small amount), the pupil image can be centered on the Lyot stop (see figure, next page).

It may be useful to think in terms of the complementary optical principle: the collimator lens projects an image of the Lyot stop at the distance of the secondary mirror. This image is the same size as the secondary mirror, and the purpose of the alignment is to make this projected image coincident with the secondary.

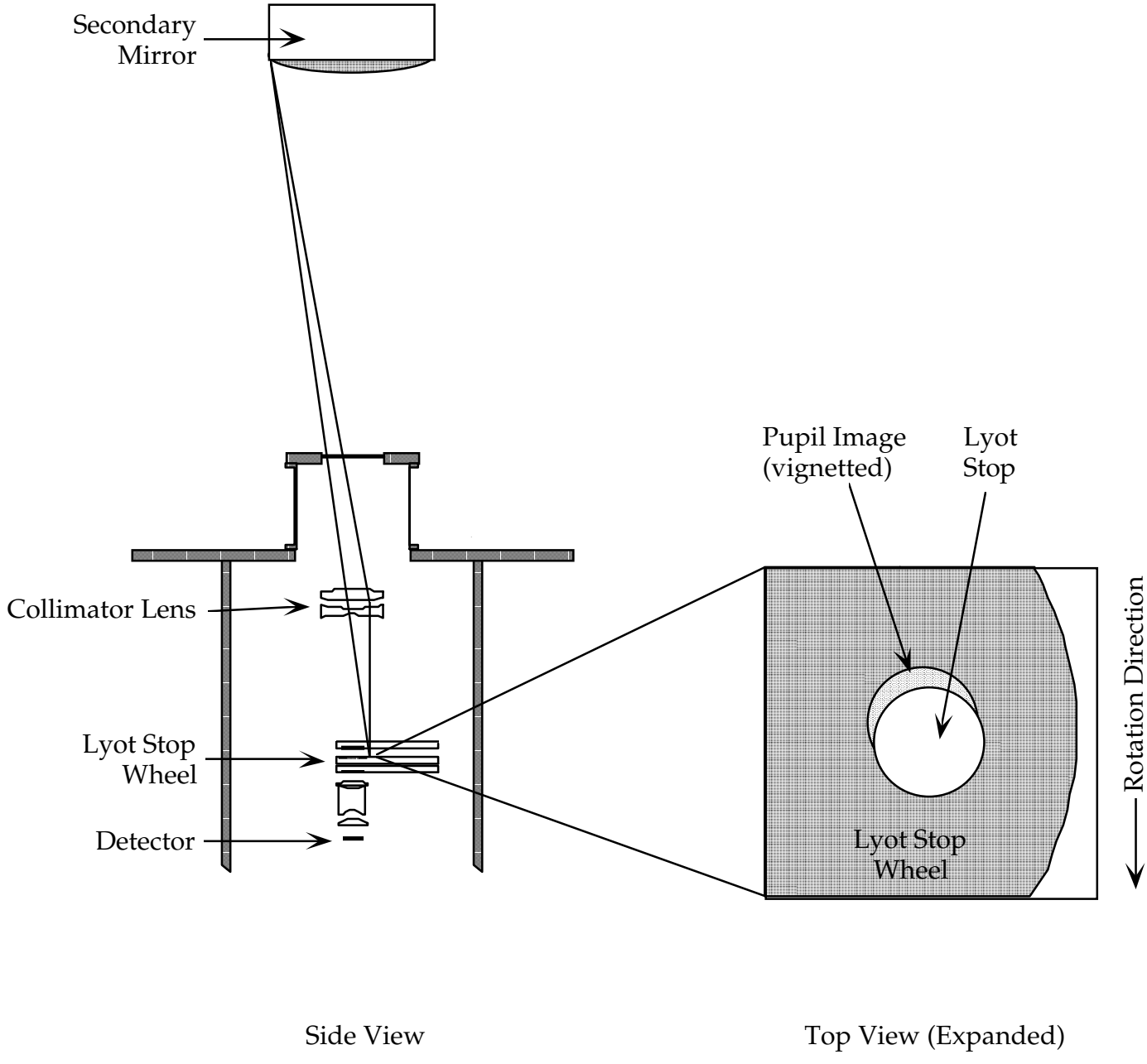


Figure 11 - MAGIC Pupil Imaging

Checking the Alignment

1. Select a fairly bright star (m_K~ 4 to 7) close to the zenith. Take an image of the star at K band in order to center it in the frame. Note that such bright stars saturate MAGIC's detector in almost all observing configurations.

2. Defocus the telescope by a large amount while taking a series of frames. The stellar image should grow to approximately one half of the full frame. You should easily see the secondary obscuration and spiders at the correct focus setting as well as the seeing turbulence pattern across the primary mirror.

3. If the alignment is perfect, the image will be completely round and symmetric. In this case, refocus the telescope and begin observing.

Adjusting the Alignment

4. If the alignment is not correct, the image will be asymmetric or cut off on one side:

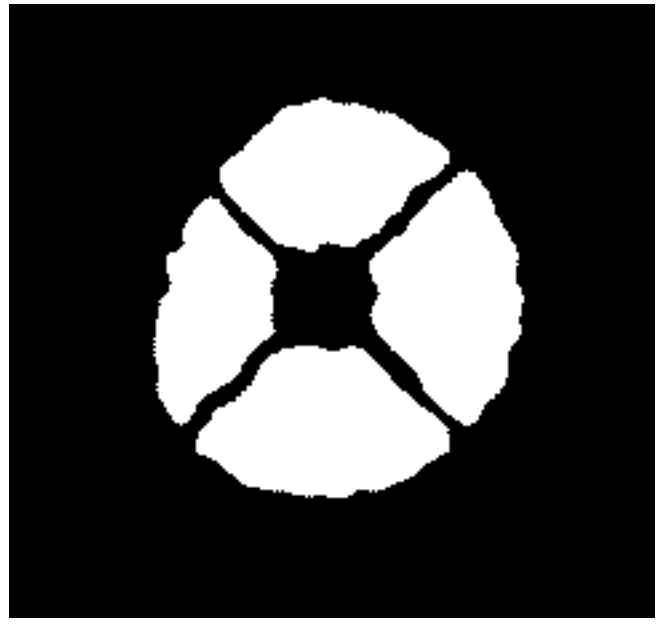


Figure 12 – Misaligned Pupil Image (Above)

5. There are two approaches to correcting misalignment: **A**. You can add or subtract a few steps from the default motor position for the Lyot stop wheel. This will help only if the asymmetry is along the direction of motion of this wheel, (east–west if the Cassegrain flange is at 0° rotation). **B**. You can adjust the tip angle of the camera mount on the telescope. The second of these procedures is described below:

Tipping the camera mount.

NOTE: You must be looking at a star near the zenith to do this. You must have the appropriate Allen wrench and a ladder to adjust the mount. Do **NOT** use the lifting platform at the 3.5 meter, since raising the floor will shut down the telescope.

There are four sets of tipping screws on the camera mount. Each set has two holding screws and one pushing screw. The following figure shows the arrangement:

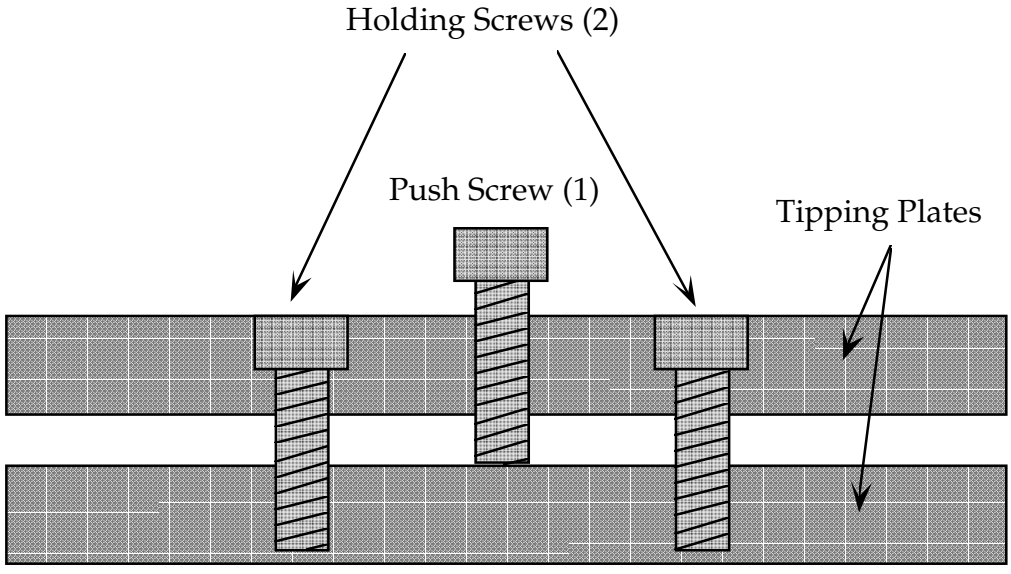


Figure 13

The camera must be hanging from the holding screws for the alignment procedure. Loosen the eight **holding** screws approximately two full turns. **NEVER loosen these screws so that the gap between the tipping plates exceeds 5 mm, since the camera can fall off the telescope.**

Tip the camera slightly by tightening one of the **holding** screws and take another (out of focus) image. If the alignment improves, keep adjusting that screw until the image is symmetric in one direction. If the alignment worsens, loosen that screw and, if necessary, tighten the opposite one. When you are satisfied with one direction, adjust the orthogonal pair of screws. Continue until the out of focus image is round and symmetric. The exact adjustment is not particularly critical. With experience, the whole procedure takes approximately 10 minutes.

When you are happy with the alignment, tighten **all** the push screws so that they are in firm contact with the other tipping plate. When all the push screws are in contact, they will define the plane for the tipping plate. Tighten all the holding bolts with the Allen wrench until they are quite snug. Tight holding bolts prevents misalignment as the telescope moves around the sky.

You should record the tipping in the MAGIC log book:

Example log entry:

29 Oct 1993, T.M. Herbst
Tipped up Blue MAGIC with High Res Opticson 3.5m f/10.
Tipping: 1mm gap in north, 1.5 mm gap in west,
0.5 mm in south, 0.0 mm in east.0

Troubleshooting

✍ If there are any problems with the GUI or other parts of the system, the following procedure will usually help:

1. Quit the GUI
2. Change to the *$home/tmp* directory and delete all files with the extension **.pid* and the file called *shmsocket*.
3. Logout from the magic22 or magic35 account.
4. Login again and type *ctrl C* **before** the openwin system starts up.
5. Type *px* and kill all processes except *tcsh*, *ps* and *more*.
6. Logout and switch off the three electronic boxes (two at the back end of the telescope and one next to the computer).
7. Wait 30 seconds.
8. Switch the electronic boxes on again, login and start up the GUI.

✍ If the system works properly but you are not able to find stars: Check to see if the TV Guider mirror is in the optical path, if it is, retract it.

✍ If you select a short integration time (<0.1 sec) the GUI automatically switches off the saturation check and the last frame display. Use the LAST button to see your current data.

Filters

Not all filters are in MAGIC at once. We guarantee that the filters marked with a ◆ symbol will be available. Please contact Peter Bizenberger for special requests and to ensure that the filters you would like to use are in the camera.
All wavelengths in µm @77K, except those marked with *. These are measured at room temperature.

Broadband filters	◆	J	1.13 - 1.37	
	◆	H	1.50 - 1.80	
	◆	K	2.00 - 2.40	
	◆	K_M,K′	1.94 - 2.30	
		K_S	2.00 - 2.32	
		BB2.28	1.51 - 2.33	
Longpass filters		LP1.2	cut on 1.2	
Narrowband filters		NB1.083	1%	He I
		NB1.094	1%	Pa γ
		NB1.237	1%	O II
		NB1.282	1%	Pa β
		NB1.644	1%	Fe II
		NB2.122	1%	H_2 1-0 S(1)
		NB2.140	1%	cont.
		NB2.151*	8.8%	(2.05 - 2.24)
		NB2.160*	2%	
		NB2.166	1%	Br γ
		NB2.220*	2%	
		NB2.248	1%	H_2 2-1 S(1)
		NB2.26	2.6%	
		NB2.295	1%	CO Band
		NB2.355	1%	
		NB2.360*	2%	
		NB2.430*	2%	
		NB2.483*	2%	
		NB1.500	50nm (3.3%)	NH_3
		NB1.580	10nm (0.6%)	cont.
		NB1.700	50nm (3%)	CH_4
		NB2.300	200nm (8.7%)	CH_4

Object List

You can create your own object list in the following format:

Object name | *Alpha* | *Delta* | *Equinox* | *pm.A* | *pm.D* | *mag* | *Comment*

Example:

HD 225023 | 0:00:11.8 | 35:32:14.0 | 1950 | 0.0000 | -0.004 | 6.96 | J=7.97
G158-27 | 0:04:12.0 | -7:47:54.0 | 1950 | -0.056 | -1.85 | 7.43 | J=9.31
HD 1160 | 0:13:23.1 | 3:58:24.0 | 1950 | 0.006 | -0.013 | 7.04 | J=7.06
HD 3029 | 0:31:02.3 | 20:09:30.0 | 1950 | -0.0001 | 0.011 | 7.09 | J=7.25
Gl 105.5 | 2:38:07.6 | 0:58:57.0 | 1950 | * | * | * | *
HD 18881 | 3:00:20.5 | 38:12:53.0 | 1950 | 0.0001 | -0.030 | 7.14 | J=7.12
G77-31 | 3:10:40.5 | 4:35:12.0 | 1950 | 0.112 | 0.15 | 7.84 | J=8.74
HD 22686 | 3:36:18.7 | 2:36:07.0 | 1950 | 0.0017 | -0.010 | 7.19 | J=7.20
HD 40335 | 5:55:37.6 | 1:51:09.0 | 1950 | -0.0005 | -0.018 | 6.45 | J=6.54
HD 44612 | 6:21:09.7 | 43:34:35.0 | 1950 | * | * | * | *

NOTE! The line | character is used as a separator between fields.
If you don't want to put in numbers in some fields, you still have to use a * character as a place holder.

The required fields are: Name, Alpha, Delta, Equinox
The optional fields are: pm.A, pm.D, mag, Comment
pm.A and pm.D are in units of arcsec/century.
The comment gets put in the fits header.

All files including an object list must have the extension: ***.objects***

Macro

You can prepare macro files in advance (see Macro Commands).
The following example shows a simple macro that moves a star to five positions on the detector, starts a read at each and saves the data.

Example:

```
read                    ;start the 1. read
sync                    ;wait until the read is finished
tele rel 25 25          ;move the telescope
save -i -f 2            ;save the data as integrated starting from the second frame
sync                    ;wait until move and save is finished

read                    ;start the 2. read
sync
tele rel -50 0
save -i -f 2
sync

read
sync
tele rel 0 -50
save -i -f 2
sync

read
sync
tele rel 50 0
save -i -f 2
sync

read
sync
tele rel -25 25
save -i -f 2
sync
```

All files including a macro should have the extension: **.**mac***

Further Reading

Dust Extinction

Rieke, G. H., and Lebofsky, M. J., 1985. ApJ, **288**, 618.

Infrared Detector Arrays

Fowler A. M., and Gatley, I. 1991 Proc. SPIE 1541 – 15.
Joyce, R. R. 1992, ASP Conf. **23**, 258 (Appended to this manual)

Infrared Standard Stars (All papers appended to this manual)

Casali, M., and Hawarden, T. 1992. UKIRT faint JHK Standards
Elias, J. H., Frogel, J. A., Matthews, K., and Neugebauer, G. 1982 AJ **87**, 1029.
Zuckerman, B., and Becklin, E. E. 1987, Ap. J. **319**, L99.

MAGIC Infrared Camera

Herbst, T. M., Beckwith, S. V. W., Birk, Ch., Hippler, S., McCaughrean, M. J., Mannucci, F., and Wolf, J. 1993, in "Infrared Detectors and Instrumentation," SPIE Conference 1946, A. M. Fowler, editor, page 605 (Appended to this manual).

Herbst, T. M. and Rayner J. T. 1993, in "Infrared Astronomy with Arrays: The Next Generation," I. S. McLean, editor (Dordrecht: Kluwer Academic Publishers), page 515 (Appended to this manual).

Noise

OH Airglow

Oliva, E. and Origlia, L. 1992, A&A, **254**, 466. (Appended to this manual)

Readout Strategies

Fowler A. M., and Gatley, I. 1990 Ap. J. Lett. 353, L53.

Appendix A: Technical Characteristics and Astronomical Performance

Array Type:	Rockwell 256x256 pixel NICMOS3 array, (HgCdTe detector + Si MOSFET non-destructive readout)
Wavelenth range:	1.0 μm - 2.5 μm
Quantum efficiency:	~0.4 at J(1.2 μm), ~0.5 at H(1.65 μm), ~0.6 at K(2.2 μm)
Bad pixels:	~ 1 %
Dark current:	< $0.5e^-$/sec
Read noise:	~ 40 e^- RMS in standard reset-read-read-mode ~ 14 e^- RMS in multiple-end-point mode
Well capacity:	~$3x10^5$ e^-
Telescopes:	The camera can be mounted on the Calar Alto 3.5 m, 2.2 m or 1.23 m telescopes

Pixel scales:

3.5m,	f/10,	Wide-field	0.81"/pix	207" field
		High-resolution	0.32"/pix	82" field
	f/45,	Wide-field	0.18"/pix	46" field
		High-resolution	0.07"/pix	18" field
2.2m,	f/8,	Wide-field	1.62"/pix	415" field
		High-resolution	0.64"/pix	164" field
1.23 m,	f/8,	High-resolution	1.2 "/pix	300" field

For high accuracy work, the scale and rotation angle should be measured during your observing run.
Changing the internal optics involves warming up and recooling the camera (about an 8 hour procedure).

Filter options: See the sensitivity table below or the filter list in the manual for available filters. Custom filters may be added for special applications. (Discuss this with Peter Bizenberger well in advance of your observing run.)

Spectroscopy: There are two grisms available.

- The ZnSe-Grism.

This grism covers either J, H or K band. Efficiency for the grism approximately 28%.
Resolution R = 370 with 2 pixels wide slit
Resolution R = 185 with 4 pixels wide slit

- The Resin-Replica-Grism.

This grism covers H & K band simultaneously or the J band alone. Efficiency approximately 78%.
Resolution R = 260 with 2 pixels wide slit
Resolution R = 130 with 4 pixels wide slit
Note: Spectroscopy is only available with high-resolution optics

except under special circumstances (discuss with P.Bizenberger).
It is not possible to change grisms during the night!

Read out options:

❍ Standard Reset-Read-Read mode:
For normal narrow-band and broad-band imaging.
Maximum tested rate 5 frames per second.
Approximate time to background-limited performance:
- less than 5 sec in broad band
- less than 100 sec in narrow band

❍ Multiple-End-Points mode:
For reducing readout noise in spectroscopy or other very low background applications.

❍ Other modes are available for high-speed full frame readout
(e.g. for speckle, up to 22 frames/sec) and very high-speed sub-array readout (e.g. for occultations, up to 100 frames per sec).

Data system:

Sun SPARC-10 dedicated to camera control.
Sun SPARC-10 for on-line data reduction. IRAF and MIDAS available for data reduction. All data are written to disk as FITS files, which are backed up via tar to a DAT tape.

Detection limits:

predicted limits for point source detections (see table below)
- f/10, wide-field optics, 0.81"/pixel
- integration time = 1 hour
- signal-to-noise ratio = 5σ
- seeing FWHM = 1"
- telescope diameter = 3.5 m
- uniform OH emission across each broad-band
- sky brightness in broad-band as measured at Calar Alto

Filter	Center μm	Width μm	Sky Mag/"	Limit flux mJy	Limit Mag
J	1.25	0.30	15.2	0.0015	22.5
H	1.65	0.30	13.6	0.0026	21.5
K'	2.10	0.34	13.3	0.0025	21.1
K_s	2.16	0.32	13.0	0.0030	20.8
K	2.20	0.40	12.7	0.0030	20.8
He I	1.083	0.011	15.6	0.0068	21.0
Pa γ	1.094	0.011	15.6	0.0069	21.0
O I	1.237	0.012	15.3	0.0075	20.7
Pa β	1.282	0.013	15.2	0.0075	20.7
[Fe II]	1.644	0.016	13.6	0.0111	19.9
H_2 S(1) v=1-0	2.122	0.021	13.2	0.0107	19.5
Br γ	2.166	0.022	12.9	0.0117	19.4
H_2 S(1) v=2-1	2.248	0.022	12.4	0.0149	19.0
cont. K	2.260	0.060	12.3	0.0094	19.5
CO band	2.295	0.023	12.0	0.0171	18.8

Appendix B: Macro Commands

The following commands and syntax should be used in MAGIC macro files. These commands can also be typed directly into the command window.

abort

syntax: abort

Aborts 'read' and/or 'macro'-execution

aperture

syntax: aperture name

Move the aperture wheel to position 'name'. The named positions are defined in the file $HOME/info/wheel2

syntax: aperture ?

Prints all possible aperture-position names and the actual one.

syntax: aperture fine steps

Moves the aperture wheel 'steps' motor steps. The sign of 'steps' may be positive or negative. 1 degree is about 40 steps. ATTENTION: !!! backlash !!!

area

syntax: area x1 y1 x2 y2

Sets the area of the image that is used for all 'save' operations.
x1/y1: lower left corner
x2/y2: upper right corner

autosave

syntax: autosave {yes,on} [-f n] [-l n] [-r n1 n2] [-1] [-i] [-d]

Enables automatic 'save'-operation after a 'read'. The switches are explained with the save-command.

syntax: autosave {no,off}

Disables automatic 'save'-operation after a 'read'.

syntax: autosave ?

Prints the status of the autosave-flag.

backup

syntax: backup path

Copies all files in the directory 'path' to /dev/ndat (DAT). You must enter the full path (beginning with '/'). You have to set the actual save-path (MAGICPATH) to a different directory than the one to be copied.
The DAT-Tape is NOT rewinded at the beginning or the end of the backup, so you can copy more than one directory to the tape.

syntax: backup -abort
Aborts a running backup.

cassoff

syntax: cassoff angle
Sets 'angle' as the cassegrain-angle for the NSEW orientation.

syntax: cassoff ?
Prints the cassegrain-angle at the NSEW orientation.

casspos

syntax: casspos angle
Sets 'angle' as the actual cassegrain angle.

syntax: casspos ?
Prints the cassegrain-angle realative to NSEW. This is 'actual cass.angle' - 'cassoff'. This value is written into the FITS-headers as CASSPOS.

cd

syntax: cd [directory]
Changes directory for 'save' operations (UNIX style).

charm

syntax: charm position {number,in,out,?}
The parameters 'in' and 'out' move the mirror to the defined in/out position. '?' returns the actual position. 'number' moves it to the absolute position.

syntax: charm move steps
Moves the mirror 'steps' times 20 nanometers.

syntax: charm define {in,out}
Defines the actual mirror position as the in/out position. Recommended values are '0' for the 'out' position and '-5780000' for the 'in' position.

syntax: charm init
Initializes the CHARM mirror position. This procedure may take up to 2 minutes. While initializing you cannot talk to CHARM.

syntax: charm mode {sky,centroid,peak,?}
Defines the CHARM mode.
'sky': Take sky for later subtraction. The mirror is not tip-tilted.
'centroid': Tip-tilt correction using the centroid of the subarray.
'peak': Tip-Tilt correction using the peak-pixel in the subarray.
'cpeak box': Tip-tilt correction unsing the centroid around a box of size 'box'.
'?': returns the actual CHARM mode.

syntax: charm xgain {value,?}
Defines or prints the gain of the piezo-controller in x-direction. Recommended value is -0.84.

syntax: charm ygain {value,?}
Defines or prints the gain of the piezo-controller in y-direction. Recommended value is -0.84.

syntax: charm rotangle {value,?}
Defines or prints the rotation angle for the piezo-controller. Recommended value is 50.

clobber
syntax: clobber {yes,no,on,off}
Enables/disables overwriting existing files. Default is 'no'.

continue
syntax: continue
Continues a paused macro.

crep
syntax: crep n
Sets the cycle repeat count. When starting a measurement with 'read', 'n' images are taken.

ctype
syntax: ctype readmode [parameters]
Sets the cycle-type. Valid cycle-types 'readmode' are:
'rr' reset.read mode (no paramters)
'rrr' reset.read.read mode (no parameters)
'multi mulitple.endpoint mode (parameter=number of endpoints)
'ramp' ramp mode (parameter=number of ramp points)
'speckle' speckle mode (parameter=number of speckle frames)
'subarray' subarray readouts only parameters: center-x center-y size
'crrr' CHARM-reset.read.read mode parameters: center-x center-y size itime(ms)

syntax: ctype ?
Prints actual cycle-type.

dir
syntax: dir [filenames]
Executes 'ls -l' in current directory. The output stops after 1 page, to proceed with the next page, enter: <RETURN> to abort the output, enter: q<RETURN>

display
syntax: display [-c numcols] [-l colormap]
syntax: ddisplay [-c numcols] [-l colormap]
Starts display-module.

'display' uses 1x1 dots per pixel.
'ddisplay' uses 2x2 dots per pixel.
'tdisply' uses 3x3 dots per pixel.
'numcols' must be in the range 4..240 (default ist 64).
'colormap' must be one of {gray,temp,heat} (default is 'gray').

eng_status

syntax: eng_status

Resquests the engineering status from the camera and prints it on the screen.
After an 'init parameters' command the returned values of 'eng_status' should be like this:
Integration time 0 = 100
Time 0 granularity = 1
Integration time 1 = 500
Time 1 granularity = 1
Cycle type = 3
Cycle type memloc = e49
Cycle repeat count = 1
Pixel time [100 ns] = 15

exit

syntax: exit

Leave the MAGIC-shell. Subprocesses are not killed.

filter

syntax: filter position

Where 'position' is a filter-macro defined in $HOME/info/fmacros. These macros imply the positions of the 2 filter wheels and the lyot-stop position. The aperture wheel is not effected.

syntax: filter ?

Prints list of avaliable filter-macros and the actual one.

fits

syntax: fits

Prints the actual FITS-header. The output stops after 1 page, to proceed with the next page, enter: <RETURN> to abort the output, enter: q<RETURN>

syntax: fits comment text

Sets 'text' in the FITS-header as COMMENT.

syntax: fits mosstep text

Sets 'text' in the FITS-header as MOS-STEP.

help

syntax: help

prints the list of commands

syntax: help command
prints information about command 'command'

history
syntax: history
Prints the command history.

syntax: !!
Repeats the last command.

syntax: !xxx
Repeats the last command that starts with 'xxx'.

infowin
syntax: infowin
Opens a window with system/camera informations.

init
syntax: init system
Initialize wheels, parameters, shared memory data base (executes 'init parametes' and 'init wheels'). Use 'init system' afer a power-on of the camera.

syntax: init wheels
Read filter/aperture - wheel database and move wheels to the ZERO-position. (detent-position). Use 'init wheels' after manual a movement of the wheels.

syntax: init parameters
Ask for username, telescope and camera parameters. Initialize shared memory. Read filter/aperture - wheel database. Set camera parameters to the values in the shared memory. Use 'init parameters' after a change of the optics (e.g. secondary mirror).

interactive
syntax: interactive {on,off,yes,no}
If you use the interactive-mode, the outputs are blocked after 19 lines, until you enter <RETURN>.

syntax: interactive ?
Prints status of the interactive-flag.

itime
syntax: itime time
Set the integration-time 'time' in seconds.

syntax: itime ?
Prints the actual integration-time

kill

syntax: kill process

Sends a 'terminate' to the following subprocesses:

'process' = display -> disp,ddisp,tdisp
infowin -> sawin,sewin
satcheck -> satcheck

load

syntax: load filename [n]

Loads 'n' FITS-files into the shared memory. Since the shared memory frame-buffers are unsigned short integers, the displayed values may be not correct. You also have to swtich the cycle-type to reset.read (rr).

logfile

syntax: logfile filename

Sets 'filename' as logfile name

syntax: logfile ?

Prints name of logfile.

ls

syntax: ls [switches] [filename]

Executes 'ls' (UNIX style)

lyot

syntax: lyot name

Move the lyot-stop wheel to position 'name'. The named positions are defined in the file $HOME/info/wheel2.

syntax: lyot ?

Prints all possible aperture-position names and the actual one.

macro

syntax: macro filename

Executes the macro 'filename'
This macro-file contains commands like you use with the shell. Be carful when invoking commands like 'read', 'telescope' or 'filter' that run in the background. Make sure that the next command does not conflict with the previous or use the 'sync' command. The default-drectory for the macros is $HOME. If you want to start the macro test.mac in $HOME/macros then enter 'macro macros/test.mac'.
You MUST NOT invoke a macro in a macro !

msio

syntax: msio drive command

Sends 'command' to motor-drive 'drive'. (prvileged command)
This command is used for test with the filter-, lyot- and aperture wheels. 'command' uses the syntax of the motor drives: e.g.:
'move 10' moves the motor +10 steps
'move -20' moves the motor -20 steps

'pos 9000' moves the motor to the absolute position 9000
'ver p' returns the absolute position in motor steps
drive = 1: lower filter
2: lyot stop
3: upper filter
4: aperture

next

syntax: next filename

Sets 'filename' as the default-filename. This filename is used, when no filename is given with the 'save' command.

object

syntax: object text

Sets 'text' as object in the FITS-header.

syntax: object ?

Prints the actual object.

observer

syntax: observer name

Sets 'name' as observer in the FITS-header. This name is used as password for the privileged commands.

syntax: observer ?

Prints the actual observer's name.

pause

syntax: pause

Stops macro execution. The macro will be continued by entering the 'continue' command or may be aborted by 'abort'.

polpos

syntax: polpos value

Writes 'value' at keyword POLPOS into the FITS-header.

pwd

syntax: pwd

Shwos actual directory for the 'save' operation. (UNIX style).

quit

syntax: quit

Leaves the MAGIC-shell and kills all subprocesses. (e.g. display,infowin,satcheck ...)

read

syntax: read [n] [-c]

Read 'n' images according to the actual cycle type. Default is the 'crep' parameter.
-c: continous read until 'abort'.

satcheck

syntax: satcheck on [limit]

Switches the saturation check on. The optional limit uses absolute counts of the A/D converter. These counts range from about 10000 - 55000. The non-linearity starts at about 40000 counts, which is the default limit. If 'sound' is on, you get a accoustic warning.

syntax: satcheck off

Switches the saturation check off. This is recomended at intgration times smaller than about 150 ms.

save

syntax: save [-f n] [-l n] [-r n1 n2] [-i] [-1] [-d] [-c] [filename]

Save frames in the shared mamory according to the actual cycle type (ctype).
-f: save from frame 'n' (= 'first frame is')
-l: save upto frame 'n' (= 'last frame is')
-r: save only frames from 'n1' through 'n2'. Default is all.
-i: save the integral of the selected frames.
-1: write all images into one FITS-file (cube).
-d: do not create FITS-files. Just dump the filled shared-memory-framebuffer.
-c: overwrite existing files (for this save-opereation only).
If no filename is given, the default filename is used.

sky

syntax: sky filename

Use 'filename' for sky-subtraction in the display and use this file as SKYFRAME in the FITS-header.

sound

syntax: sound {on,off}

Enables/disables sound after some operations like 'read', 'filter', 'aperture', 'lyot', 'telescope', 'macro', or as a warning if the saturation check is on. Default is 'off'.

syntax: sound ?

Prints the sound status.

sync

syntax: sync [read] [tele] [wheel]

Waits for termination of the read, telescope, filter, lyot-stop and aperture moving process.

telescope

syntax: telescope absolute hr min sec dg min sec [equinox]

Moves the telescope to the absolute position
alpha: 'hr' 'min' sec'
delta: 'dg' 'min 'sec'
Be carefull with negative declinations. If 'dg' = 0 'min' has to have the minus (`-`).

syntax: telescope relative dx dy

Moves the telescope 'dx' 'dy' arc-seconds.

syntax: telescope position

Returns the telescope position.

verbose

syntax: verbose {on,off,yes,no}

If you set 'verbose yes', you will get more output to the screen. e.g. while executing a macro the system will print every command (and the line number), so you always know which macro-line is executed. Default is 'yes'.

syntax: verbose ?

Prints status of the verbose-flag.