FLI MicroLine 16803-65 b/w CCD-Camera

by Rolf Geissinger

Nowadays it's not very easy to choose the perfect astro camera from all the models offered by various manufacturers. It is best to gather as much information as possible in advance and to be familiar with technical terms and their meaning (such as binning, sampling, pixel size, full well capacity, etc.)

Following should be considered carefully:

- maximum budget (including filters and filter wheels)
- favoured objects (extensive nebulae or rather tiny galaxies / planetaries)
- cooled astro-CCD or digital camera (DSLR)
- monochrome or color
- size of the sensor
- free aperture and stability of the focuser
- pixel size
- full well capacity at different wavelengths
- cooling performance

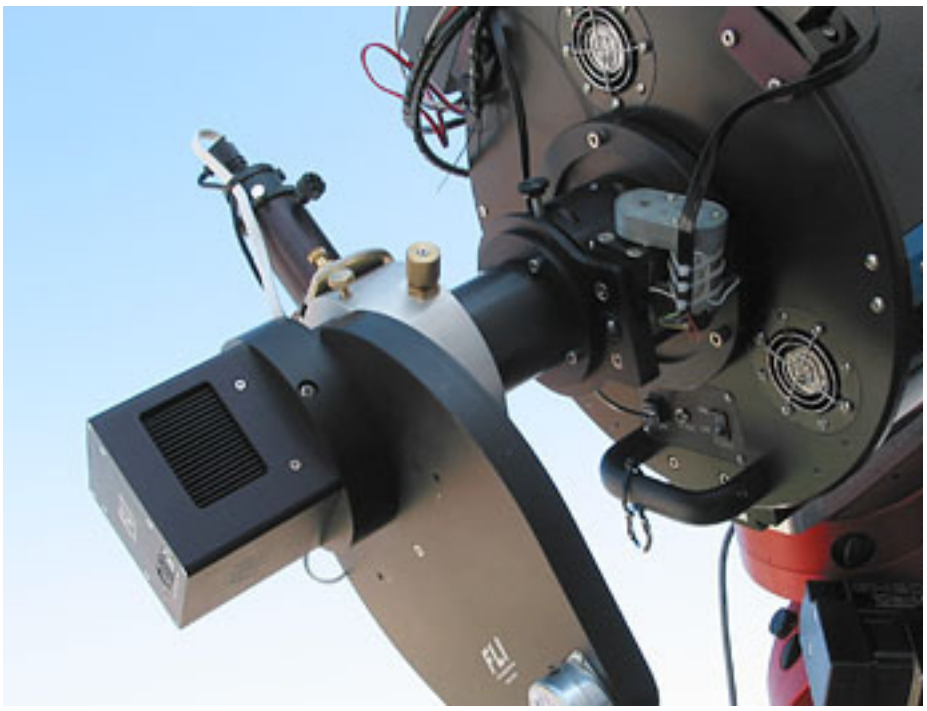
- anti-dew technology
- camera weight
- acoustical noise level during operation (cooling fans)

First place it must be considered, at which telescope(s) the camera should finally be used. You need to decide if the camera should be procured to fit the telescope or the other way round. Personally I included the following aspects before making my choice:

1. I wanted the new camera to have a monochromatic chip. I knew about the advantages of an OSC-camera (one-shot-camera or color camera), but with the light-polluted sky at my observation site I was planning to practice astro-photography with narrow-band filters (H-alpha, OIII and SII). In principle this is also possible with a one-shot-camera, but the achieved resolution is consequently lower.
2. As a second criterion I was considering the following:
My PlaneWave 12.5" CDK can fully illuminate a corrected image field of 52 mm diagonal, my TEC 140 can even achieve areas of 6 x 7 cm with it's original flattener. So why should I choose a chip that is much smaller than that? This would be a loss of the telescope's performance. Therefore I wanted to use a full frame CCD-sensor (36 x 24mm) at least.

I quickly realised that there was not a very big choice at the market. In this category, cameras with the Kodak KAI 11002 chip are relatively common. But this sensor has the disadvantage of not having very high quantum efficiency (only 25% with H-alpha) due to it's interline-technology. Also the full well capacity of 60000 e- is not outstandingly high.

These properties were definitely better with front illuminated chips. While interline-chips use every



FLI ML 16803-65 with CFW-5-7 filter wheel und self-built off axis guider
(perfectly constructed and machined by Kurt Schneider – Many thanks again!)

second line for capturing the image (advantage in transfer speed), front illuminated chips can collect light over the entire chip surface. Of course download speeds are decreased, but this is unimportant with exposure times of several minutes.

Highly-sensitive back illuminated chips dropped out due to their relatively large pixels (15µm and more), high price and etaloning-effect.

Chip size is not the only thing that should be taken into account. Another very important criterion for choosing the perfect camera is the pixel size. This is all about sampling. The image scale should be in the range from 0.7 to 3 arcsec per pixel. Owing to the usual seeing conditions, the value should especially not be below a lower boundary of 0.7” / px.

The sampling can easily be calculated with following formula:
Sampling = 3438 x pixel size (in mm) x 60 divided by the focal length (in mm)
The result is a sampling value with the unit “arcseconds per pixel”
Example:
Pixel size = 9 µm = 0.009 mm
Focal length = 2541 m4m
--> Sampling 0.73”/pixel

Based on this result, the pixels of my camera should not be smaller than 9µm.

My shortlist consisted of the large front-illuminated chips from Kodak, namely the KAF 09000 with 12 µm pixels and the KAF 16803 with 9 µm pixels. Both chips are square with 36.8 mm x 36.8 mm edge length. The diagonal of the chip is therefore 52 mm. Given the smaller pixels and the expected higher resolution, I eventually decided to take the 16803 chip. Moreover I have been told by experienced users, that the RBI-handling (the elimination of ghost-images which are typical for front-illuminated-chips) is significantly easier with the KAF 16803.

Well, but which camera brand should I choose now? I realized soon that it is easy to overview the list of brands.

The American manufacturers SBIG, Apogee and FLI (Finger Lakes Instrumentation) offer cameras with such a large chip. Given that SBIG could not deliver the new STX-series at that stage and I wanted to relinquish of an internal guiding chip, only Apogee and FLI remained. There was no significant difference in the costs of comparable cameras from the two companies.

According to some reports, Apogee cameras can need up to 45 minutes until they reach their final chip temperature. FLI devices cool down to the regulated temperature within 5-6 minutes. In addition, FLI is not only offering the ProLine series, but also the MicroLine series which is significantly smaller and more importantly lighter but still has nearly the same performance.

Only the cooling capacity and the readout-noise are slightly worse than in the ProLine. Since in the MicroLine camera there is only one large, slow-running fan (compared to the three relatively small

fans in the ProLine), less noise is emitted. This is an important feature for a balcony observatory because the sleep of your neighbours should not be disturbed excessively.

So the die was cast: I was going to choose a FLI ML 16803-65.

Because of the convenient dollar exchange rate at that time and after having sorted out many details, I decided to purchase the camera directly from FLI in the USA. I corresponded with the general manager via email and none of my questions (and I had lots of them) remained unanswered.

Connections from left to right: Voltage supply 12V, external trigger, USB 2.0-data-interface

I had a very good feeling throughout and in the end everything worked out great. The delivery date was slightly exceeded, but you need to bear in mind that these cameras are normally produced on demand. This means that the device you get is not a mass product, but an individually manufactured camera of high quality. This is proved by a test protocol and a checklist, ticked off step by step.

The Camera technology:

During the assembly, the CCD-sensor is very precisely aligned plane-parallel to the housing in order to avoid that images are out of focus at one side. The large chip is cooled down with a Triple-TEC (triple-stage Peltier-element). The chip-temperature drops down to 50°C below ambient within 5 minutes and is regulated to a precision of +/-0.1°C.

It is very important that the cooled chip is not covered with dew or freezes. Differently to other manufacturers, FLI solves this problem with hermetic sealing the housing and noble gas filling. Therefore no drying-cartridge is needed. Up to now I have never had any problems with dew inside the cam.

A general problem with front illuminated CCD's are appearing ghost-images (RBI - residual bulk image). They are caused by residual charges from the previous shot picture, which appear on the following image as a ghost-image (very straightforward explanation).

For this reason there are infrared diodes located in the camera body which automatically flood all the pixels after each picture (on demand). After this, the charges are again read out completely and cancelled afterwards. It is possible to adapt the number of floodings to your needs. This procedure usually lasts roughly one minute.

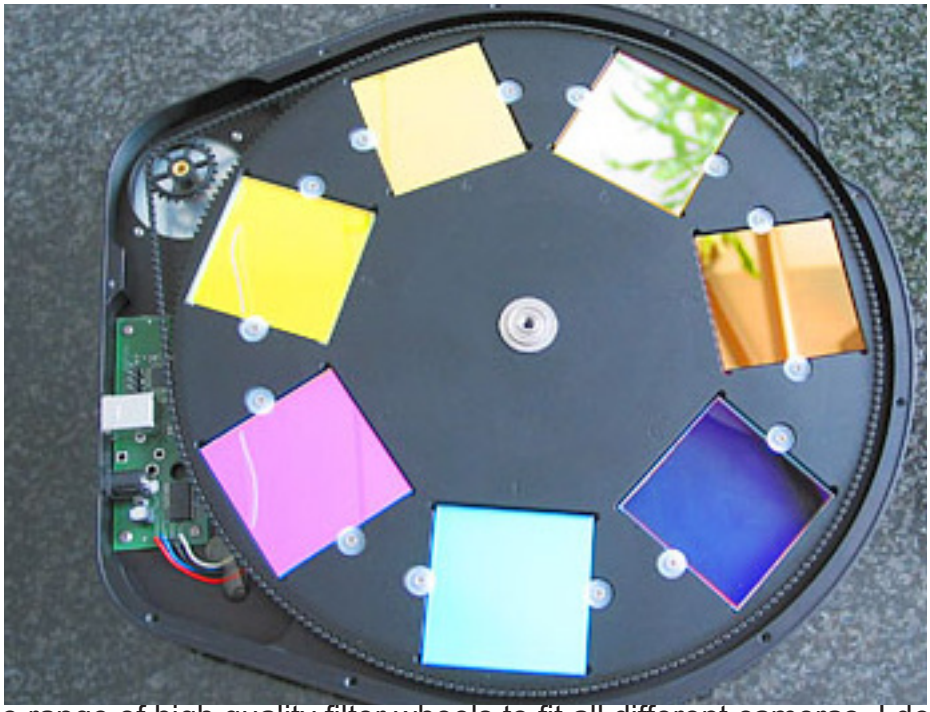
Given that front-illuminated chips do not have an electronic shutter, a mechanical shutter must be used. Integrated in the ML 16803 there is a 65 mm six-sheet shutter with am minimal aperture time of approximately 40 ms. Therefore it is not possible to take images with an exposure time lower than 40

65 mm - Shutter

ms like may be needed for flat-fild images for example.

In order that the shutter's opening and closing does not leave a typical "star" on the flat field image, it is necessary that flats are exposed for 3-4 sec at least. Thus the illumination of the flats needs to be significantly dimmed.

MaxIm DL completely and comfortably controls and supports the camera. There are no problems in operating the cam properly. Also the driver setup (USB 2.0) worked fine and there were no complications.



FLI offers a wide range of high quality filter wheels to fit all different cameras. I decided to purchase a CFW-5-7. This milled filter wheel can hold 7 unframed 50 mm x 50 mm filters. I use filters from the Baader-Planetarium company:
Luminance, red, green, blue, H-alpha (7 nm), OIII (8.5 nm) and SII (8 nm)

The filter wheel is moved by a chain drive. The wheel itself has a double ball bearing. The position is not determined with an infrared-diode, but magnetically with a Hall-sensor. This avoids that any IR-light could accidentally hit the CCD-sensor. The mechanical extraction of the filter wheel is extremely stable and it works blamelessly. MaxIm DL recognizes this filter wheel and therefore it can be controlled fully automatic.

FLI-service:

Purchasing your equipment directly from USA is always a bit risky because your dealer is not next door. At the beginning, my camera always recorded a diffuse artefact on the same chip area which looked like a dark stripe. Given that this defect could be found on every single image, I started to look for a possible reason. Apparently there was a tiny fuzz or scratch somewhere on the cover glass. But even when observing the cover glass under a microscope I could not find any damage. After carefully examining the glass with a DSLR-sensor loupe and a very special incidence of light I was able to see a tiny scratch at the cover glass.

A short e-mail to FLI with a description was sufficient to send the camera in for reparation. The dispatch from my entry door, the repair and the transport back to my home – it all lasted only 9 days.

Camera and filter wheel with self-built off-axis-guider

The camera now works excellently, the artefact has disappeared.

Due to the very large CCD-sensor, common 2” nose pieces are not sufficient to adapt both the camera and the filter wheel to the focuser. For this purpose FLI offers a wide range of adapters.

It is important that you do not underrate the enormous weight of the camera, guiding camera, filter wheel and off-axis guider and the resulting long crank (determined by the back focus). Therefore the

Photo lens (Mamiya 200 /2.8 medium format) adapted to CCD-camera.

focuser needs to have adequate dimensions. With the constellation I use, there are more than 4 kg (!) of photographic equipment loading the focuser. Thus a usual 2” focuser is completely inappropriate.

My personal conclusion:

The practical test has shown that my considerations before purchase have been quite right in the end. The specifications and descriptions of camera models and filter wheels do correspond with reality. Different values for maximal cooling performance are stated. Temperatures around -70°C can only be reached if ambient temperature is -20°C. Due to different systems, large chips are normally not cooled as much as smaller chips are. Realistically it is possible to cool the CCD-sensor of the ML 16803 down to approximately 52°C below ambient. For my opinion this is totally sufficient.

Support, camera handling, mechanical concept, acoustical noise production, stability of drivers and last but not least the quality of the raw images do not let much room for further improvements.

Manufacturer:

FLI Finger Lakes Instrumentation

Technical information:

- CCD-sensor: Kodak KAF-16803 (b/w) full-frame CCD imaging sensor
- Number of pixels: 4096 x 4096 (eff.) / 16.8 Mpx
- Active chip size: 36.8 x 36.8 mm (52.1mm diagonal)
- Pixel size: 9 µm x 9 µm (square pixels)
- Readout noise: 10.35 e- RMS at 1 MHz (documented in test record)
- Quantum efficiency: approx. 61% (green), approx. 45% (H-alpha)
- Linear Full Well : 100.000 e-
- Anti-Blooming: 100x
- Operating voltage: 12V
- Operating temperature: -30°C to +45°C
- Shutter (mechanical): 65 mm
- Data range: 16 bit
- Data transfer: 8 MHz and 1 MHz (approx. 5 sec and 20 sec download full frame image)
- Interface: USB 2.0

Shortest exposure: 40 ms

Position of sensor surface: 30.23 mm to camera flange 43.8 mm to CFW 5-7 filter wheel flange
Cooling: regulated triple TEC down to 52°C below ambient at +/- 0.1°C
Supported Software: FLI-Grab, MaxIm DL plugin, AstroArt plugin, CCDSOFT plugin
Size / weight: approx. 94 x 94 x 127 mm / approx. 1270 g
Filterwheel: CFW 5-7 with seven positions for 50 x 50 mm filters
Weight: approx. 1800 g