Moravian Instruments

CCD Cameras for Astronomy

North America and Pelican nebulae in narrow-band
Image by Laurent Bourgon and Didier Chaplain
CCD camera G4-16000

G4 Cameras with Back Side Illuminated Detectors

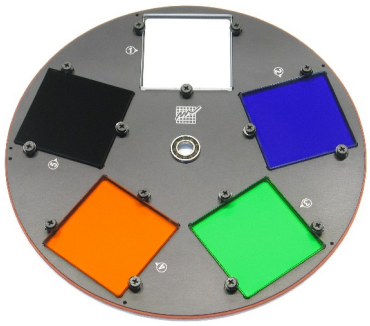
Back-Illuminated CCD detectors provide highest possible quantum efficiency, often exceeding 90% through the wide range of the visible light wavelengths. Beside top-class sensitivity, back-Illuminated detectors offer high linearity and dynamic range, so they are extremely suitable for demanding scientific applications. On the other side, exclusive detector parameters come on price. Back-Illuminated detectors are significantly more expensive compared to front-illuminated ones, which must be reflected in the price of the cameras which employ them.

The G4-4000BI camera uses CCD42-40 detector from E2V Technologies. Other camera properties (camera head construction, shutter, compatibility with filter wheels, USB and Ethernet interface etc.) are identical to other G4 camera models using front-illuminated KAF detectors.

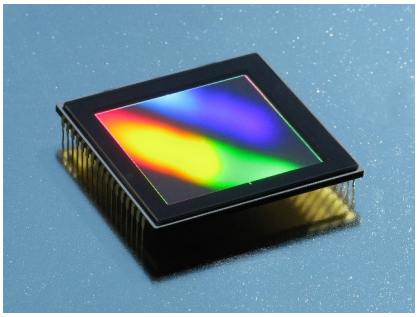
Model	CCD	ABG	Color mask	Resolution	Pixel size	Chip area
G4-4000BI	CCD42-40	no	none	2048 × 2048	13.5 × 13.5 µm	27.6 × 27.6 mm

G4 Large Format Cameras

G4 cameras are capable of using use large CCD detectors with 37 × 37 mm area, which is 50% more than the area of a classical film frame. Precisely regulated cooling keeps the CCD at constant temperature, which allows high quality image calibration. Cameras can be equipped with liquid-coolant heat exchanger to cool down the hot side of the Peltier TEC modules, beside the two magnetic levitating fans used in air cooled cameras. G4 cameras are equipped with near-IR preflash electronics to cope with the Residual Bulk Image effect.



There is a mechanical shutter inside the camera head. In contrast to the smaller G3 and G2 cameras, filter wheel for 50 × 50 mm square filters (round filters of 50 mm diameter cause vignetting on such large CCD chips) cannot be placed inside the camera head due to limited space. However, it is possible to connect en external filter wheel for 5 large filters to the G4 camera as the camera head already contains a connector for external filter wheel control. Even a larger external filter wheel with 7 positions for 50 × 50 mm square filters is available for G4 cameras as well.

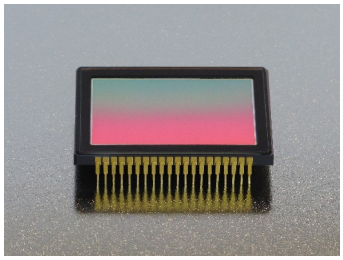


The used CCD detectors are equipped with so-called “anti-blooming gate” (ABG), which drains the over-abundant charge from saturated pixels. ABG ensures the round images of bright stars, without disruptive blooming spikes. This is particularly important for large format cameras, which often provide wide field of view. Moreover, compromising the linearity of the CCD by ABG is negligible is has no effect on photometric or astrometric observations. G4 cameras are used for astronomical research also considered to be the ultimate camera for astrophotography.

Model	CCD	ABG	Color mask	Resolution	Pixel size	Chip area
G4-9000	KAF09000	yes	none	3056 × 3056	12 × 12 µm	36.7 × 36.7 mm
G4-16000	KAF16803	yes	none	4096 × 4096	9 × 9 µm	36.9 × 36.9 mm

G3 Medium Format Cameras

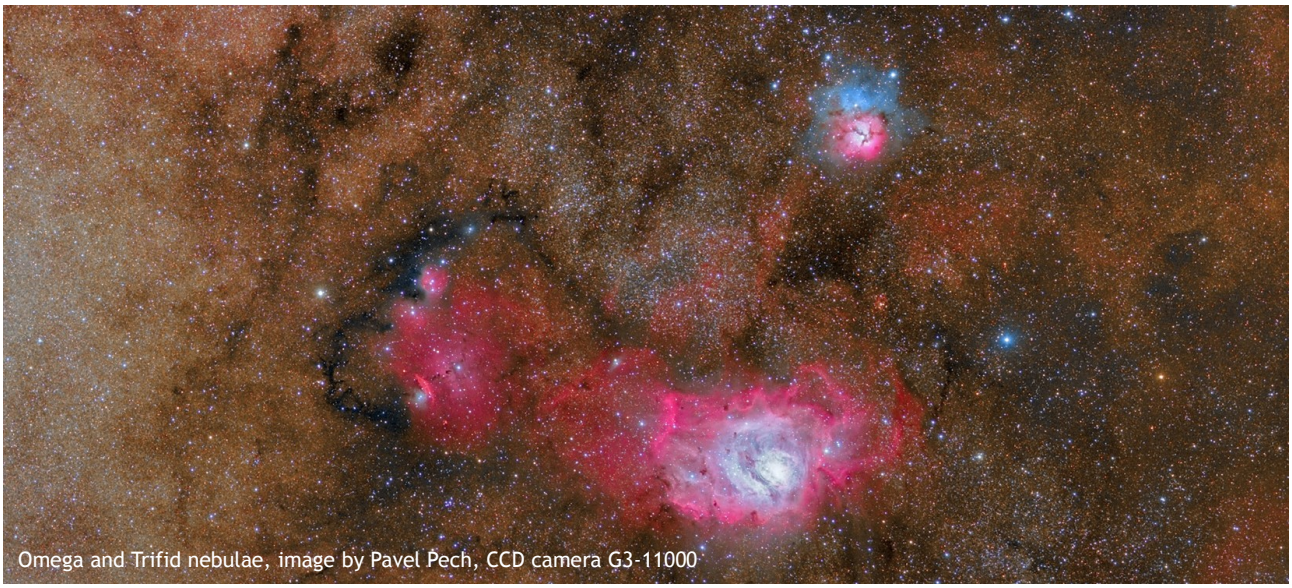
G3 cameras can be equipped with CCD detectors up to 24 × 36 mm. Precisely regulated and efficient cooling of the CCD up to 45°C (80°F) below ambient temperature allows high quality image calibration. There are mechanical shutter and filter wheel with 5 positions for 2-inch (or 50 mm) round filters inside the camera head, which allows these cameras to be used in unattended, robotic setups. G3 cameras can also be combined with external filter wheels with 7 positions for 2-inch (or 50 mm) filters.



Kodak KAF CCD chips with linear response to light are suitable for scientific applications. Large area of these detectors suits long focal length of big telescopes and large pixels ensure high image dynamic range. The G3-1000 camera fits especially well telescopes with focal length of many meters due its large 24 × 24 µm pixels.

Astrophotographers appreciate Kodak KAI detectors with ABG and electronic shutters. The anti-blooming feature ensures round images of bright stars, which cannot be avoided especially on wide-field images. The G3-11000 model offers unbeatable ratio between camera price and detector area.

Model	CCD	ABG	Color mask	Resolution	Pixel size	Chip area
G3-1000	KAF1001E	no	none	1024 × 1024	24 × 24 µm	24.6 × 24.6 mm
G3-6300	KAF6303E	no	none	3072 × 2048	9 × 9 µm	27.7 × 18.4 mm
G3-11000	KAI11002	yes	none	4032 × 2688	9 × 9 µm	36.3 × 24.2 mm
G3-11000C	KAI11002	yes	RGBG (Bayer)	4032 × 2688	9 × 9 µm	36.3 × 24.2 mm



Omega and Trifid nebulae, image by Pavel Pech, CCD camera G3-11000

G2 Small Format Cameras

G2 cameras were designed for demanding scientific applications and for high-end astrophotography. Very high quantum efficiency (more than 85% in the case of the G2-3200 camera) allows capturing of very faint objects. High quality electronics provide uniform images without artifacts and read noise is limited by the CCD detectors themselves only. Regulated cooling of CCD up to 50°C (90°F) below ambient temperature significantly reduces the detector's dark current. Cameras have integrated a filter wheel with 5 positions for 1.25" filters in threaded cells or with 6 positions for glass-only filters and a mechanical shutter.

G2-0400, G2-1600 and G2-3200 cameras with non-ABG Kodak KAF CCD chips are suitable for scientific applications, requiring both high quantum efficiency and linear response to light. These cameras are popular e.g. among variable star observers or extragalactic supernova hunters.

G2-2000 and G2-4000 cameras with Kodak KAI CCD chips with ABG are suitable for astrophotography—the anti-blooming of KAI CCDs eliminates charge blooming when bright stars appear in the field of view.

G2-8300 camera with Kodak CCD with ABG is also suitable for astrophotography, especially in combination with short focal length telescopes due to the small pixels and large resolution. These cameras produce stunning images at relatively low cost.

Model	CCD	ABG	Color mask	Resolution	Pixel size	Chip area
G2-0402	KAF0402ME	no	none	768 × 512	9 × 9 µm	6.9 × 4.6 mm
G2-1600	KAF1603ME	no	none	1536 × 1024	9 × 9 µm	13.8 × 9.2 mm
G2-3200	KAF3200ME	no	none	2184 × 1472	6.8 × 6.8 µm	14.9 × 10.0 mm
G2-8300	KAF8300	yes	none	3358 × 2536	5.4 × 5.4 µm	18.1 × 13.7 mm
G2-8300C	KAF8300	yes	RGBG (Bayer)	3358 × 2536	5.4 × 5.4 µm	18.1 × 13.7 mm
G2-2000	KAI2020	yes	none	1604 × 1204	7.4 × 7.4 µm	11.8 × 8.9 mm
G2-2000C	KAI2020	yes	RGBG (Bayer)	1604 × 1204	7.4 × 7.4 µm	11.8 × 8.9 mm
G2-4000	KAI4022	yes	none	2056 × 2062	7.4 × 7.4 µm	15.2 × 15.2 mm
G2-4000C	KAI4022	yes	RGBG (Bayer)	2056 × 2062	7.4 × 7.4 µm	15.2 × 15.2 mm

Numerous telescope (or microscope, photographic lens or other optical system) adapters are available for Gx cameras. These include standard 2” barrel, T-thread (M42×0.75), M48×0.75 thread as well as Canon EOS and Nikon F-mount bayonet adapters.




G0 & G1 Guiding Cameras

G0 and G1 CCD cameras are ideally suited for imaging of the Moon, planets and bright deep-sky objects. High sensitivity, low noise, fast image download, electronic shutter and integrated standard “autoguider” port also allow G0 and G1 cameras to guide astronomical telescope mounts. Thank to their capability to integrate light for a long time these cameras can guide the mount even using dim stars, which are invisible for common TV and web cameras. Robust construction, small dimensions, easy manipulation and powerful software make G0 and G1 cameras ideally suited for beginner astrophotographers.

Model	CCD	ABG	Color mask	Resolution	Pixel size	Chip area
G0-0300	ICX424AL	yes	none	656 × 494	7.4 × 7.4 µm	4.9 × 3.7 mm
G0-0300C	ICX424AQ	yes	RGBG (Bayer)	656 × 494	7.4 × 7.4 µm	4.9 × 3.7 mm
G0-0800	ICX204AL	yes	none	1032 × 778	4.65 × 4.65 µm	4.8 × 3.6 mm
G0-0800C	ICX204AK	yes	RGBG (Bayer)	1032 × 778	4.65 × 4.65 µm	4.8 × 3.6 mm
G0-2000	ICX274AL	yes	none	1628 × 1236	4.4 × 4.4 µm	7.2 × 5.4 mm
G0-2000C	ICX274AQ	yes	RGBG (Bayer)	1628 × 1236	4.4 × 4.4 µm	7.2 × 5.4 mm

G0 cameras have simple cylindrical body resembling a 1.25” eyepiece, G1 cameras employ larger case, allowing usage of active cooling. Integrated fan keeps the CCD temperature close to ambient temperature, often more the 10°C (20°F) lower compared to closed designs. Lower CCD temperature results in lower dark current. Despite of the cooling fan, both models are powered by the USB line, requiring only single USB cable from the host PC to the camera.

Guiding algorithms are performed in the PC, which allows the use of sophisticated techniques (star centroid measurement up to one tenth of pixel). Both G0 and G1 cameras provide standard autoguider port for mount control and can handle precise timing of guiding pulses.

Model	CCD	ABG	Color mask	Resolution	Pixel size	Chip area
G1-0300	ICX424AL	yes	none	656 × 494	7.4 × 7.4 µm	4.9 × 3.7 mm
G1-0300C	ICX424AQ	yes	RGBG (Bayer)	656 × 494	7.4 × 7.4 µm	4.9 × 3.7 mm
G1-0301	ICX414AL	yes	none	656 × 494	9.9 × 9.9 µm	6.5 × 4.9 mm
G1-0301C	ICX414AQ	yes	RGBG (Bayer)	656 × 494	9.9 × 9.9 µm	6.5 × 4.9 mm
G1-0800	ICX204AL	yes	none	1032 × 778	4.65 × 4.65 µm	4.8 × 3.6 mm
G1-0800C	ICX204AK	yes	RGBG (Bayer)	1032 × 778	4.65 × 4.65 µm	4.8 × 3.6 mm
G1-1200	ICX445ALA	yes	none	1296 × 966	3.75 × 3.75 µm	4.9 × 3.6 mm
G1-1200C	ICX445AQA	yes	RGBG (Bayer)	1296 × 966	3.75 × 3.75 µm	4.9 × 3.6 mm
G1-1400	CX285AL	yes	none	1392 × 1040	6.45 × 6.45 µm	9.0 × 6.7 mm
G1-1400C	CX285AQ	yes	RGBG (Bayer)	1392 × 1040	6.45 × 6.45 µm	9.0 × 6.7 mm
G1-2000	ICX274AL	yes	none	1628 × 1236	4.4 × 4.4 µm	7.2 × 5.4 mm
G1-2000C	ICX274AQ	yes	RGBG (Bayer)	1628 × 1236	4.4 × 4.4 µm	7.2 × 5.4 mm

External Filter Wheels

External Filter Wheels for G2, G3 and G4 CCD cameras offer more positions compared to internal filter wheels, embedded into camera head. External filter wheels do not need to be connected to the host PC with a separate USB nor a serial cable and do not need independent power supply. Only single short 8-wire cable connects the external filter wheel to the camera head. The external and internal filter wheels are indistinguishable from the software point of view and same drivers are used to control them.

External filter wheels cannot be used together with internal ones. G2 and G3 cameras with an internal filter wheel cannot be attached to an external filter wheel—the camera is manufactured either with internal filter wheel or with connectors and thinner front case for attaching the external filter wheel. There is no internal filter wheel option for G4 series of CCD cameras, these cameras can be used with an external filter wheel only.

Model	Camera model	Number of positions	Filter dimensions
EFW-2S-12	G2	12	D31 mm, 1.25" (M28.5x0.6 cells)
EFW-2S-10	G2	10	D36 mm
EFW-2S-7	G2	7	D50 mm, 2" (M48×0.75 cells)
EFW-3S-7	G3	7	D50 mm, 2" (M48×0.75 cells)
EFW-4M-7	G4	7	D50 mm, 2" (M48×0.75 cells)
EFW-4M-5	G4	5	50 × 50 mm
EFW-4L-9	G4	9	D50 mm, 2" (M48×0.75 cells)
EFW-4L-7	G4	7	50 × 50 mm

Off-Axis Guider Adapters

Standard T-thread (M42×0.75), M48 and M68 adapters can be replaced with variants incorporating a mirror and an upper port for guiding camera. Off-axis guiders are then tightly integrated with the camera body and M42 and M48 variants ensure 55 mm back focal distance for various optical elements (field flatteners, coma correctors etc.) and still reflecting the incoming light to guider camera before it reaches the filters. This is particularly important when using filters with very low light transmission like UV, Blue or even narrow-band filters.

Guider camera port is designed for any camera equipped with standard 1.25” nosepiece. It is compatible with all G0 autoguiders and even G1 cameras reach focus when connected using shorter version of C-mount to 1.25” adapter.

Camera Ethernet Adapter

Gx series of CCD cameras are equipped with USB 2.0 interface capable of 480 Mbps transfer speed. Besides the high transfer speed the USB interface brings a number of advantages to the user. USB connector includes lines providing power for connected devices, so that the small G0 and G1 cameras are connected to the computer with a single cable and there is no need for separate power source and cord (device consumption is naturally limited, but the G0/G1 cameras comply with this limit with a big margin). The USB cables are standardized and therefore there is no possibility of a wrong connection. Also, the program support is designed so that the user does not have to perform any configuration and setting. The USB device is simply connected and used (this concept is called “Plug-and-Play”).

On the other hand, the disadvantage of a USB connection is the limited distance between the device and the computer. A single USB cable can be only 5 m long. Using the so-called USB active extension cables can extend this distance to 10 or 15 m, but the cable connection and active USB elements are necessary every 5 m.

The Gx Camera Ethernet Adapter solves the problem of connecting the Gx cameras over long distances by offering remote connection of cameras over Ethernet network. There is a compact computer with Intel Atom processor in the core of the Ethernet Adapter. The software is located on an mSATA SSD (Solid State Disk), firmly attached to the main board, and there are no moving parts in the whole device that guarantees long-term reliability, durability and resistance to shocks or vibrations.

The Ethernet interface supports a transmission speed at 1 Gbps (10/100 Mbps compatible) and allows integration to all common local area networks. The compact unit uses the same supply voltage of 12 V DC and power connectors like G2, G3 and G4 cameras. Thus, it is possible to use an identical power source for the Ethernet Adapter as for the rest of the system.

The single Gx Camera Ethernet Adapter includes 4 USB 2.0 ports and allows simultaneous connection of up to 4 cameras. The image download speed is almost unaffected, especially when 1 Gbps Ethernet interface is used.

Software support

Scientific Image Processing System (SIPS) software package is shipped with every camera (the package can be also downloaded from the web site for free). SIPS offers numerous functions starting with camera and filter wheel control, exposure series and guiding. It also supports other devices (GPS receivers, focusers, telescope mounts, dome controllers, …) and additional features like image calibration, blinking, matching and stacking of multiple images, shows profiles and calculates statistics, exports images to common formats beside the native FITS support etc.

Universal ASCOM drivers for all Gx cameras and filter wheels is also available. Beside the ASCOM, native drivers for various software packages (e.g. MaxIm DL, TheSkyX, AstroArt, …) are also available. Support for other software packages is gradually added.

All Gx cameras are supported by native drivers for all 32-bit and 64-bit versions of Windows (XP to 8) and also for various 32-bit and 64-bit flavors of Linux.

Partial list of Moravian Instruments customers

Canada-France-Hawaii Telescope (CFHT), USA
Max-Planck-Institut (MPI), Germany
Instituto de Astrofísica de Andalucía (IAA-CSIC), Spain
Astronomical Institute of the Academy of Science of the Czech Republic (Ondrejov Observatory)
Pierre Auger Observatory, Argentina
Institute of Physics of the Academy of Sciences of the Czech Republic
Department of Astronomy, Faculty of Mathematics and Physics, Charles University, Prague
National Research Council of Canada
University of Toronto, Canada
Department of Theoretical Physics and Astrophysics, Faculty of Science, Masaryk University, Brno
Joint Laboratory of Optics, Palacky University Olomouc, Czech Republic
Astronomical Institute of the Slovak Academy of Sciences, Slovakia
Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic
University Heidelberg, Germany
University Würzburg, Germany
University of South Bohemia in Ceske Budejovice, Czech Republic
Institute of Photonics and Electronics of the Academy of Sciences of the Czech Republic
Institute of Chemical Technology, Prague
Institute of Plasma Physics of the Academy of Sciences of the Czech Republic
J. Heyrovský Institute of Physical Chemistry
Faculty of Machnical Engineering, Czech Technical University in Prague
Institute of Analytical Chemistry of the Academy of Sciences of the Czech Republic
Technical University of Ostrava, Czech Republic
Faculty of Electrical Engineering and Communication, Brno University of Technology
Faculty of Biomedical Engineering, Czech Technical University in Prague
University of West Bohemia, Plzen, Czech Republic
Brno Observatory and Planetarium, Czech Republic
Observatory Valasske Mezirici, Czech Republic
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Orion nebulae, image by Pavel Pech, CCD camera G3-11000