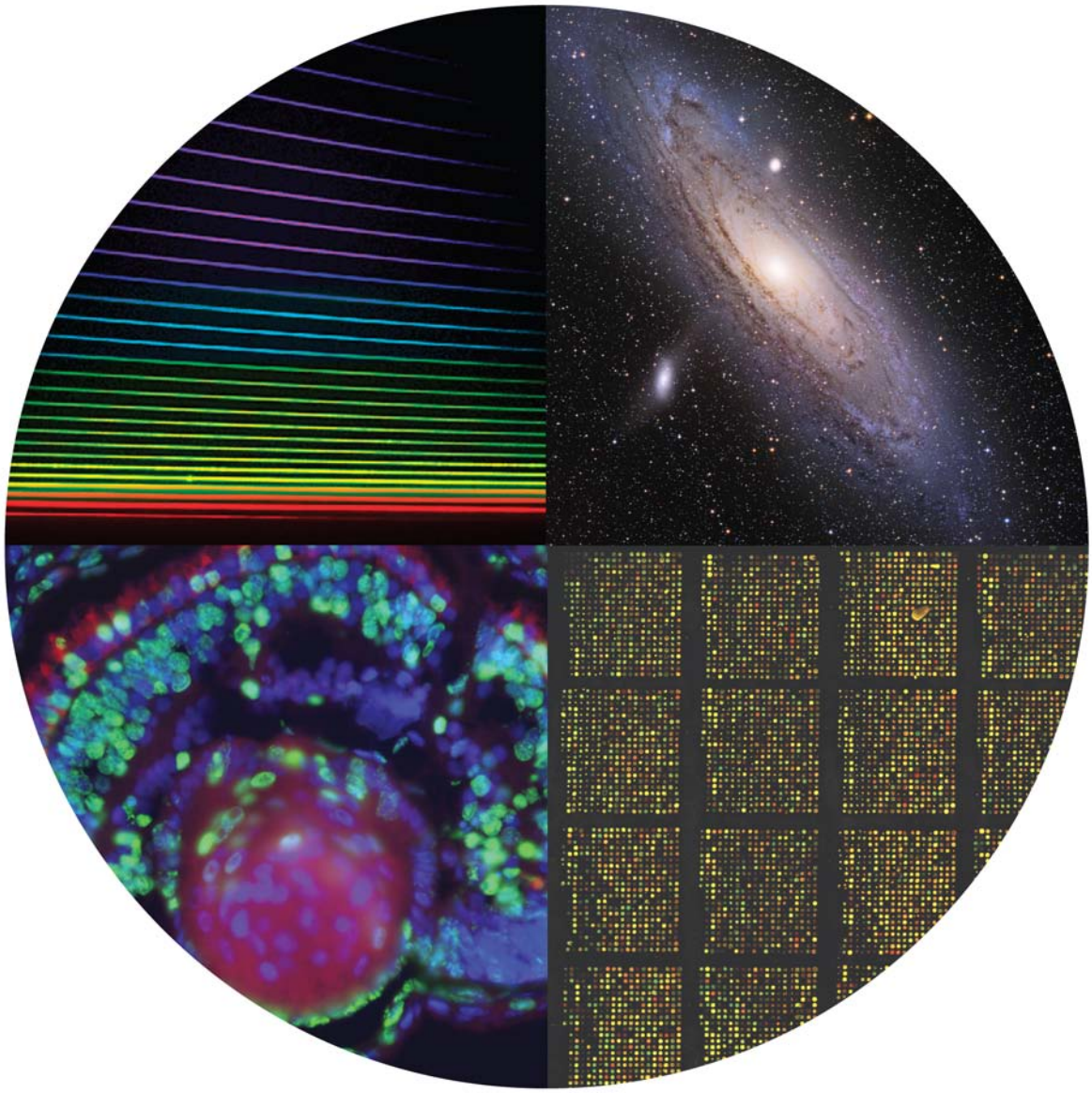

High Performance Cooled CCD Camera Systems 2011

Apogee IMAGING SYSTEMS

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Fluorescence image courtesy Dr. David Rapaport, UCSD; echelle spectra, courtesy Catalina Scientific; astro image courtesy Adam Block.

Apogee IMAGING SYSTEMS

HIGH PERFORMANCE COOLED CCD CAMERAS

SYSTEM OVERVIEW

Apogee Alta® and Ascent® cameras are designed for a wide range of demanding scientific applications.

In Ascent, we reduced the size and cost of our electronics and housings, while at the same time maintaining the key features of our popular Alta Series cameras. We added high-speed 16-bit electronics and some new sensors with resolutions up to 16 megapixels.

The larger Alta cameras offer lower noise and deeper cooling than the Ascent cameras. They also support a broad selection of CCDs, from interlines to full frame front-illuminated to back-illuminated, from large pixels with exceptionally high dynamic range, to very high resolution. You can also choose from a broad selection of housings, from our standard housing, to one with deep cooling, or a short back focal distance (low profile), or a wide entrance aperture (wide angle). Most models are available with either fan or liquid circulation methods for removing heat from the back of the camera.

For both camera series, the direct USB 2.0 link between camera and computer allows easy installation, portability and fast data transfer rate. Ascent maintains compatibility with our Alta ActiveX drivers, as well as Linux and Mac OS X drivers.

QUALITY

Our goal is steady refinement in every aspect of our cameras, including product consistency, product lifetimes, ease of adaptation and use, and added hardware and software features. We also continue to refine our procedures, documentation, and customer recordkeeping. We're proud of the thousands of cameras that we've delivered, but even more proud that so little effort is needed to keep them all working. An Apogee camera may become obsolete, but it is extremely unlikely that it will stop working. Your biggest worry: you may wear out an electromechanical shutter every few years.

In our effort to improve our process, we've achieved the following benchmarks:

- FCC compliance
- CE compliance
- ROHS compliance
- ISO-9000 compliance (in process)

VALUE

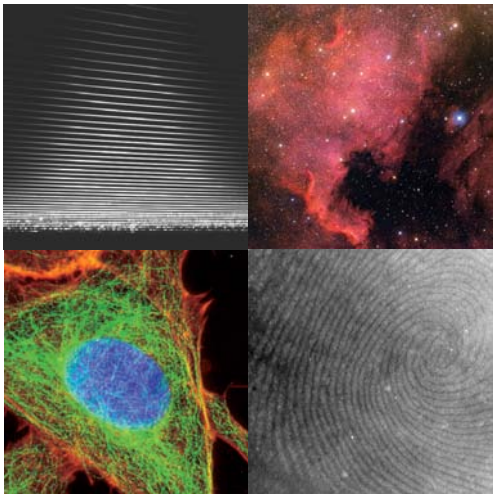
We supply the best price/performance in the industry. Researchers rely on Apogee to provide excellent value for their investment. OEMs rely on Apogee Imaging Systems to deliver ultra-reliable products on time and with consistently high quality. Please contact our sales team for a quotation for any quantity, large or small.

EASE OF INTEGRATION

All of our systems run on a single universal software driver. If you integrate control of one Apogee system into a custom software environment, you automatically have support for any of our systems. Based on the feedback we get from our customers, integration is simple and straightforward. We offer an ActiveX driver for Windows environments. Our Linux driver and source are posted on sourceforge. We also offer a Mac OSX driver.

CUSTOMIZATION

Perhaps you need to incorporate custom optical elements into your camera. Apogee Imaging Systems has a long history of working with customers to modify our product line to fit their requirements. Let us know how we can optimize our cameras to best suit your application.



DIVERSITY ADDS STRENGTH

Since 1993, Apogee Imaging Systems (formerly Apogee Instruments) has been manufacturing cooled CCD cameras for scientific applications. Our cameras are now used in more than 50 countries, from government and private research laboratories to the best of world-class professional observatories. Apogee cameras have been used for a wide variety of applications, including spectroscopic analysis of water, soil, and gems; detection of anthrax; development of methods and technologies for detection of land mines and improvised explosive devices (IEDs); analysis and detection of contaminants at nuclear reactors; imaging of fingerprints without chemicals; x-ray inspection of car parts; fluorescent imaging of cell tissues and microtitre plates; munitions testing; laser beam profiling; poacher surveillance; radiotherapy dosimetry; retinal imaging; mammography; optics testing; discovery of thousands of astronomical objects; and radiometry of a wide variety of light sources.

By expanding into broad markets with diverse demands, Apogee has had to develop a wide variety of technologies to solve our customers' problems. Our astronomy and spectroscopy customers demand low noise, high sensitivity, and high quantitative accuracy. Our life science customers demand speed and ease of use. All customers groups are constantly pushing for higher performance at lower prices.

ASCENT® versus ALTA® SERIES CAMERAS

There are many factors to consider when choosing a CCD camera: cost, resolution, speed, noise, cooling, sensitivity, housing size. Other features may contribute to a system's overall suitability, but most of these features are shared by the Alta® and Ascent®. In general, consider the following key requirements to determine the optimal platform:

Alta:
Low readout noise
Maximum cooling
Back-illuminated CCDs
Very large format CCDs
Optional ethernet interface

Ascent:
Low cost
High speed readout
Compact housing

INTEGRATION CD

Apogee has collected all of our brochures and mechanical drawings onto an Integration Starter Kit CD, together with software drivers and documentation. Free on request. Pictured below: covers of our astronomy, life sciences, spectroscopy, and OEM brochures, all of which are available for download at **www.ccd.com**

ASCENT®

LOWER COSTS

Many applications require clean, quantitative images, but do not require the ultimate in cooling or low readout noise. The Ascent is an ideal solution for many applications where several thousand dollars may be more important than a few electrons.

HIGHER THROUGHPUT

Ascent was designed to operate at speeds up to the maximum allowed by USB2. Digitization speed is programmable so you can choose your ideal trade-off between speed and noise. All speeds digitize at a full 16 bits.

COMPACT HOUSING

The Ascent's smaller, more lightweight housing fits in many places that the larger Alta cannot.

ALTA®

LOW READOUT NOISE

Alta's readout electronics were designed to minimize readout noise. The higher speed software-selectable 12-bit mode is intended for focussing, and not optimized for low noise.

ADVANCED COOLING

To maximize heat dissipation, Alta's large inner chamber, back plate, and heatsinks are machined from a single block of aluminum. The four fans have four programmable speeds.

BACK-ILLUMINATED CCDs

Back-illuminated CCDs are much more expensive than front illuminated CCDs, so they are chosen when necessary for maximum signal-to-noise under low light conditions. Their higher dark current per square millimeter requires the higher cooling of larger Alta housing.

VERY LARGE FORMAT CCDS

The Alta platform is available in several housing sizes, accomodating CCDs up to 50mm on a side.

ASCENT® versus ALTA® SERIES CAMERAS

The primary differences between the Ascent and Alta Series cameras: Ascent is very compact with much lower costs, much faster digitization, and programmable gain. Alta is larger, with better cooling, and lower noise electronics. See the chart below for an overview of the differences. See camera data sheets to get details of a specific model.

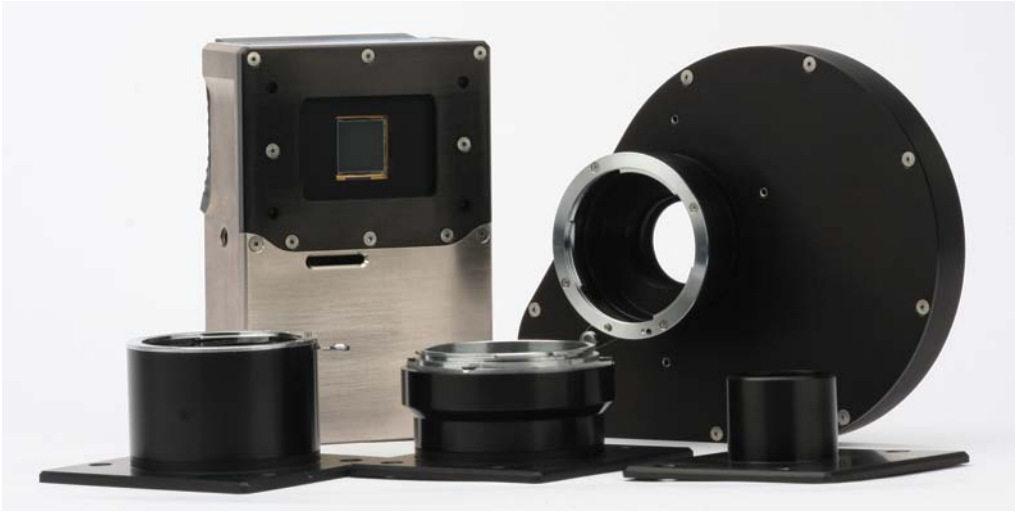
Feature	Ascent®	Alta®
Digitization	16 bit, programmable speed	Fast 12 and slower 16 bit
Maximum throughput	Up to 16 Mpixels/sec (Note 1)	Up to 7 Mpixels/sec (Note 2)
Dual channel interline readout	Standard (on applicable CCDs)	N/A
Progressive scan for interlines	Standard	
Video focus mode	Standard	N/A
Maximum cooling	40C below ambient (Note 2)	70C below ambient (Note 2)
Temperature regulation	± 0.1°C	
Programmable gain & offset	Standard	N/A
USB2 interface	Standard	
Electromechanical shutter	N/A	Standard, internal (Note 3)
Programmable fan speed	N/A	Standard
Field upgradeable firmware	Standard	
Chamber window	Fused silica	
Peripheral communications	8 pin mini-DIN connector	
General purpose I/O port	Standard	
Programmable LEDs	Standard	
Power input	6V	12V
Internal memory	32 Mbytes	
Types of CCDs supported	Interline CCDs only	Back- & Front-Illuminated; Interline
External triggering	Standard	
Image sequences	up to 65535 images	
Hardware binning	Up to 8 x height of CCD	
Subarray readout	Standard	
TDI readout & Kinetics mode (Note 6)	N/A	Standard (See note 4)
Back focal distance	0.32” (0.81 cm)	0.69” (17.5mm) and up (Note 2)
C-mount interface (Note 7)	Optional, external (Note 5)	Standard for D01 & D03 housings
Software universality	Standard	
Housing size	4.8” x 3.25” x 2.25”	6” x 6” x 2.5” (Note 6)
Warranty (Parts & labor)	2 years	
Warranty against condensation	Lifetime	

Note 1	Maximum single channel throughput 12.5 MHz; dual channels at 8 megapixels/sec each
Note 2	Varies from model to model.
Note 3	Electromechanical shutters are standard for full frame CCDs, and optional for interline CCDs.
Note 4	Does not apply to interline CCDs.
Note 5	CCDs >1” video format are generally too large for C-mount optics.
Note 6	Some housings are larger.

ASCENT® SERIES CAMERAS: 0VERVIEW

PROGRAMMABLE DIGITIZATION

Unlike previous generations of Apogee cameras with fixed digitization rates for each bit depth, the Ascent® cameras feature programmable readout rates using 16-bit digitization. You can choose the best trade-off between noise and readout speed image-by-image. Some CCDs, like the Kodak interline transfers, can read two channels at up to 8 MHz each, for a total throughput of 16 megapixels per second. Other CCDs, like the Sonys, typically have a single channel maximum throughput rate of 12.5 MHz. See individual camera data sheets for specifics regarding each camera system.



PROGRAMMABLE GAIN AND OFFSET

All Ascent models feature programmable gain and bias offset programmable in the analog-to-digital converter.

ANTI-REFLECTIVE COATED FUSED SILICA OPTICS

The standard chamber window for the Ascent system is fused silica.

SINGLE 6V POWER SUPPLY

Ascent camera systems include a 6V international power supply (100V-240V input), but can be operated from a clean 6V source.

COMPACT DESIGN

The Ascent systems are extremely lightweight (0.65 kg) and compact. At 4.7” x 3.2” (11.9 x 8.1 cm) and only 1.3” (3.3 cm) thick with no external electronics, the Ascent is a marvel of compact electronics. The standard back focal distance for all models is about 0.32” (0.8 cm).

ASCENT FILTER WHEEL

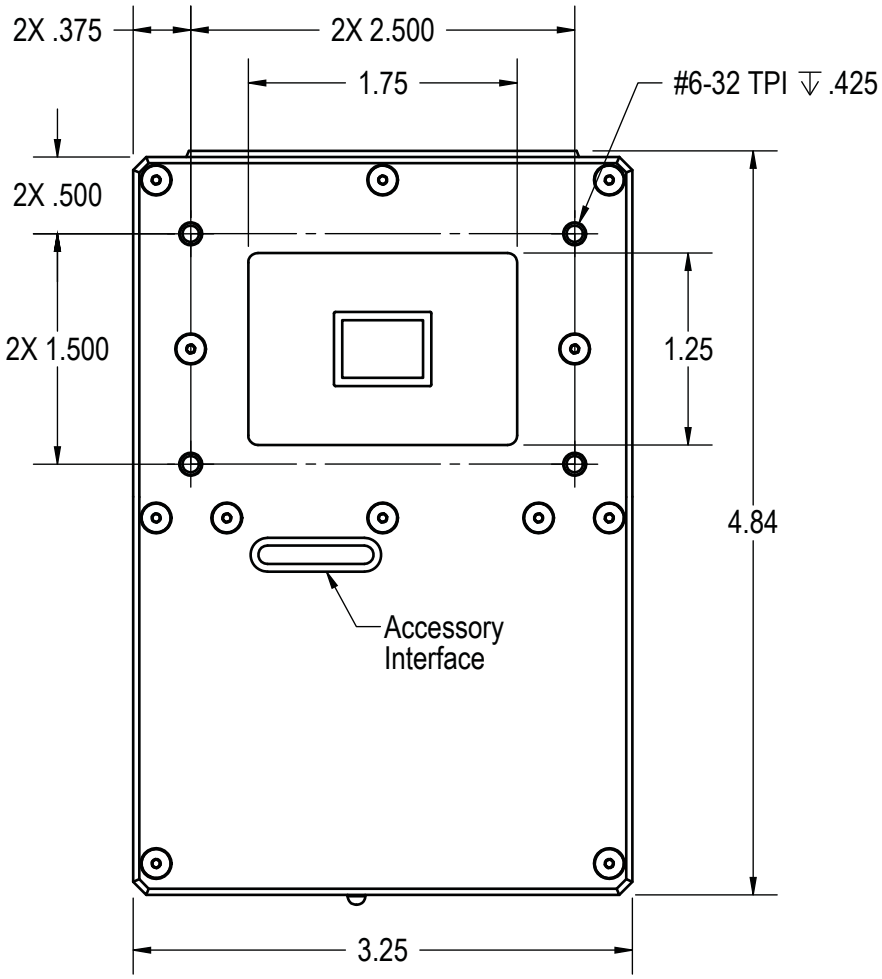
Ascent filter wheels are available for 6-positions for 1” (25mm) filters or 8-position for 1.25” (31mm) filters (shown with optional Nikon F-mount lens adapter).

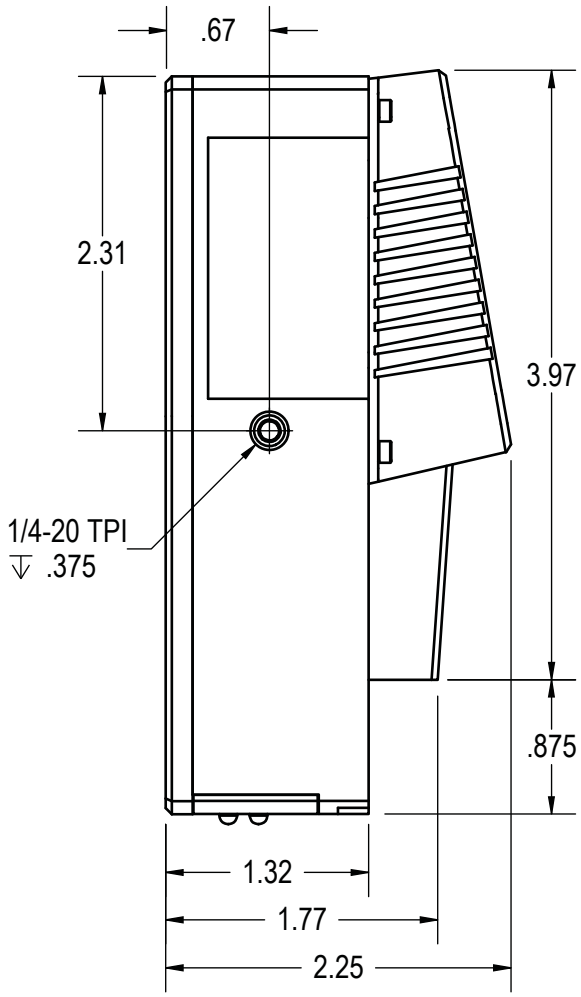
ASCENT MODELS (ALL CCDs ARE INTERLINE TRANSFER)

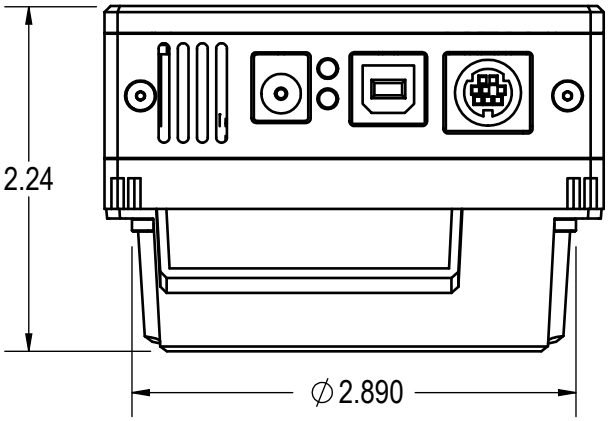
Model	CCD*	Array	Pixels	Pixel size (microns)	CCD Size (mm)	Area (mm2)	Diagonal (mm)	Video size (“)
A340	KAI-0340	684 x 484	313K	7.4	4.8 x 3.6	17.2	6.0	0.37
A1050	KAI-1050	1024 x 1024	1.1M	5.5	5.6 x 5.6	34.8	8.3	0.52
A2050	KAI-2050	1600 x 1200	1.9M	5.5	8.8 x 6.6	58.1	11.0	0.69
A2150	KAI-2150	1920 x 1080	2.1M	5.5	10.6 x 5.9	62.7	12.1	0.76
A2000	KAI-2020	1600 x 1200	1.9M	7.4	11.8 x 8.9	105.1	14.8	0.93
A4050	KAI-4050	2336 x 1752	4.2M	5.5	11.3 x 11.3	126.9	15.9	1.0
A4000	KAI-4022	2048 x 2048	4.2M	7.4	15.2 x 15.2	229.7	21.4	1.34
A8050	KAI-8050	3296 x 2472	8.1M	5.5	18.1 x 13.6	246.5	22.7	1.42
A16000	KAI-16000	4872 x 3248	15.8M	7.4	36 x 24	866.5	43.3	2.7
A29050	KAI-29050	6576 x 4384	28.8M	5.5	36 x 24	872	43.5	2.7
A205	ICX205	1360 x 1024	1.4M	4.65	6.3 x 4.8	30.1	7.9	0.49
A285	ICX285	1360 x 1024	1.4M	6.45	8.8 x 6.6	57.9	11.0	0.69

* KAI = Kodak and ICX = Sony. For complete CCD specifications, including cosmetic grading, see data sheet from manufacturer.

Ascent® Mechanical Drawings







CFW25-6R with Nikon F-mount lens adapter mounted on Ascent® camera

Ascent® Part Numbering System / CFW Compact Filter Wheels for Ascent

A1D-00285MS-FS

Housing
A1

Channels
S = Single
D = Dual

CCD
00205 = Sony ICX205 (A205)
00285 = Sony ICX285 (A285)
0S340 = Kodak KAI-0340S
0D340 = Kodak KAI-0340D
01050 = Kodak KAI-1050 (A1050)
02050 = Kodak KAI-2050 (A2050)
02150 = Kodak KAI-2150 (A2150)
02020 = Kodak KAI-2020 (A2000)
04050 = Kodak KAI-4050 (A4050)
04022 = Kodak KAI-4022 (A4000)
08050 = Kodak KAI-8050 (A8050)
16000 = Kodak KAI-16000 (A16000)
29050 = Kodak KAI-29050 (A29050)

Window
A = Standard fused silica, AR coated
C = Custom

Cooling
F = Fan assist
N = No assist

CCD Grade
(as defined by manufacturer)
S = Standard
1 = Grade 1
2 = Grade 2

CCD Type
M = Monochrome
C = Color

Back focal distances for Ascent range from 0.275" to 0.296" (optically corrected).

CFW Compact Filter Wheels for Ascent

CFW25-6R filter wheel

The CFW25-6R and CFW31-8R filter wheels provide fast, compact filtering solutions for the Ascent® series of imaging systems. The wheels plug directly into the front of the Ascent camera, using the integrated Ascent Peripheral Interface for power and control. A 2-inch slip fit adapter is available for mounting on telescopes. Coupled with the optional Nikon F-mount lens adapter, the camera and filter wheel can be easily mounted to any F-mount lens, or to any microscope with an Nikon F-mount camera adapter.

Model	CFW25-6R	CFW31-8R
Filter Size	25mm or 1" round	31mm or 1.25" round
Filter Type	Drop-in	Threaded or Drop-In
Positions	6	8
Filter Thickness	2 to 5mm	2 to 6.5 mm
Weight	0.85 lb. (0.4 kg)	1.85 lb. (0.85 kg)
Thickness	0.775" (1.97 cm)	0.925" (2.35 cm)
Power Input / Interface	Ascent Peripheral Interface	

CFW31-8R showing threaded 1.25" filters from Astrodon, Baader, Orion, and Astronomics, as well as single and dual 31mm drop-in filters from Astronomics

ALTA® & ASCENT®: SHARED FEATURES

TWO-YEAR WARRANTY

All Apogee cameras have a standard two-year warranty and a lifetime guarantee against condensation in the camera.

INTERNAL MEMORY

32 Mbytes of SDRAM image memory is included in the Alta® U Series and Ascent® camera heads. Local memory serves some important functions:

First, with any USB2.0 connection, consistency in download rates cannot be guaranteed. Some manufacturers go to great lengths to attempt to lock Windows® up during downloads to ensure that no pattern noise results from breaks in the digitization process. The Alta and Ascent systems buffer the image transfer to protect from noise-producing interruptions.

Second, on heavily loaded USB2 ports, slower USB1.1 applications, the maximum digitization rate could be limited without a local buffer. Local image memory allows very fast digitization of image sequences up to the limit of the internal camera.

HARDWARE BINNING

Every Alta camera supports hardware binning. Horizontal binning may be up to 8, and vertical binning may be up to the height of the CCD, with a maximum of 4095. Binning can be used to increase frame rate, dynamic range, or apparent sensitivity by collecting more light into a superpixel. See additional detail under CCD University on our website.

D09L Housing
with optional FW50 filter wheel

SEALED INNER CHAMBERS

The sensors for Alta cameras are sealed into an inner chamber filled with argon. The chamber has a lifetime guarantee against condensation.

PROGRAMMABLE LEDs

Two LEDs on the side of the cameras can be programmed to show status of a variety of the camera functions, such as the camera has reached the set temperature, the shutter is open, or the camera is waiting for an external trigger. Alternatively, the LEDs can be turned off if you are concerned about stray light.

SOFTWARE

An ActiveX driver is included with every Alta system. The driver is universal to all Apogee cameras, including legacy AP and KX cameras. If you write custom code for an Apogee camera, you won't have to change it later if you change models. Our cameras are also supported by other programs like Image Pro Plus, MaxIm DL/CCD, and CCDSoft. Linux and Mac OS X drivers are also available.

UPGRADEABLE FIRMWARE

The Alta systems load all camera operating code on camera start. These configuration files can be updated via the web as we add features and make improvements.
Each camera head has coded information identifying the type of system, its configuration, and type of CCD used, as well as the firmware revision in use. This allows automatic configuration of the camera in the field and better customer support from our offices.

SUBARRAY READOUT

Alta cameras support readout of an arbitrary sub-section of the array in order to speed up frame rate. (Please note that reading half the array, for example, does not increase the frame rate by two because parallel clocking is normally about 10X faster than serial clocking.

EXTERNAL TRIGGERING

Alta camera systems accept external hardware trigger signals through their camera I/O port for a number of purposes. Software and hardware triggers can be used together. For example, a software or hardware trigger may be used to initiate a single exposure or a sequence of exposures of a specific duration and specific delay between exposures. Alternatively, a software trigger may be used to start a sequence, and the external trigger can be used to trigger each subsequent image in the sequence. In addition, the external trigger can be used to trigger row shifts for time-delayed integration, or can be used to trigger block shifts for kinetic imaging.

PROGRESSIVE SCAN (CONTINUOUS IMAGING)

Interline transfer CCDs first shift charge from the photodiode in each pixel to the masked storage diode, and then march the charge through the storage diodes to the serial register. Acquisition of a new image in the photodiodes during readout of the previous image is called "progressive scan." Alta cameras support progressive scan with interline CCDs.

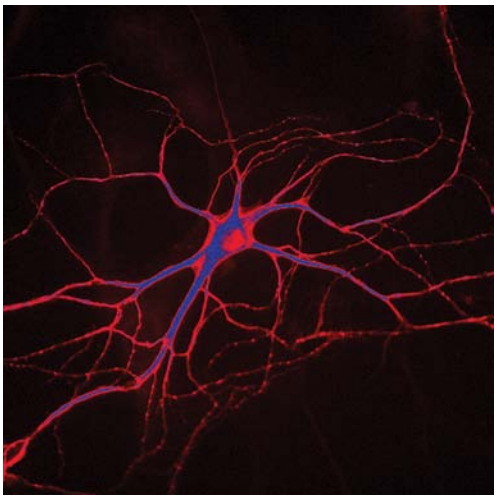


Image courtesy of Prof. Dale Hunter, Tufts University, MA

SPECIAL MODES OF OPERATION

ALTA® & ASCENT®

IMAGE SEQUENCES

Image sequences of up to 65535 images can be acquired and transferred to camera / computer memory automatically. A delay may be programmed between images from 327 microseconds to 21.43 seconds. (This does not mean you can acquire images every 327 microseconds; it means you can program a delay of 327 microseconds between the end of a readout and the start of the next exposure.)

Altas support three types of image sequencing:

Application-Driven Sequencing:
This is the most common form of image sequencing. The application merely takes a specified number of successive images. This type of sequencing is suitable when the time between image acquisitions is not short and where slight differences in timing from image to image are not important.

Precision back to back sequencing
Altas incorporate a firmware controlled back to back image sequencing mode suitable for image-image intervals from 327uS to a maximum of 21.43 seconds in 327uS intervals. This provides for precision spacing of images in a sequence where windows applications cannot respond.

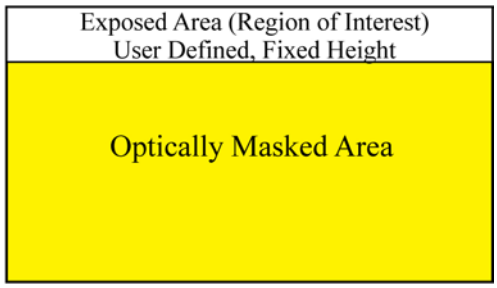
Fast back to back sequencing *(Ratio Imaging - Interlines only)*
This is a special form of precision back to back sequencing designed for a fixed <1 microsecond spacing between a pair of interline CCD exposures. The caveat with this mode is that the exposure times for each image must be greater than the readout time for the image. See separate brochure on interline transfer CCDs for details.

www.ccd.com

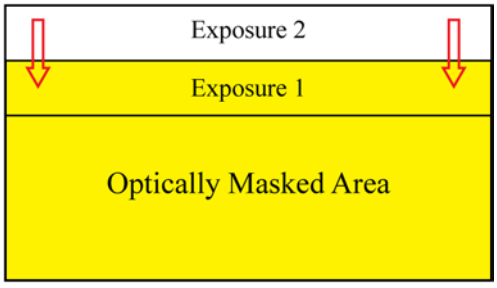
ALTA

KINETICS MODE

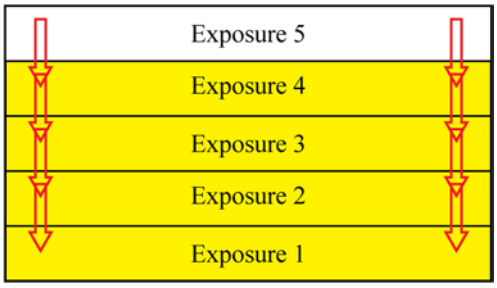
Kinetics Mode assumes that the user has optically masked off all but the top most section of the CCD. This exposed section is illuminated, shifted by x rows, then exposed again until the user has exposed the entire surface of the CCD with y image slices.



The image in the exposed area is shifted to the masked area per software command, pre-set shift frequency, or external trigger. The number of rows per section is predetermined and constant.



When the number of desired exposures has been reached, or the CCD has been filled (whichever comes first), the entire array is read out and digitized. If you want to use the entire CCD including the exposed area, then the light source needs to be shuttered after the final exposure (externally, electronically, or electromechanically). or using an electromechanical shutter).



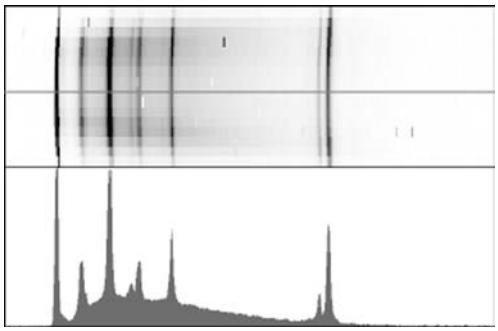
ALTA

TIME-DELAYED INTEGRATION

More formally known in astronomy as time-delay integration (TDI), this technique is a powerful tool for applications requring the scan of an area larger than the CCD's field of view. The image is clocked down the CCD in syncronization with the object's movement. The CCD must be precisely aligned with the movement of the scene.

The simplest way to illustrate TDI is an astronomical application. The telescope is kept stationary, and the CCD is precisely aligned with the sky. As the Earth rotates and the sky drifts, the image on the CCD is precisely clocked to continue building the image. When the image reaches the last row, it is read to the host computer and added to a continuous strip of sky.

The TDI capability utilizes a 25 MHz time base (Ascents use a 48 MHz time base) and local memory to achieve consistent high resolution performance. TDI mode allows the user to adjust the row shift rate. Timing may be adjusted in 5.12 microsecond increments to a maximum of 336 milliseconds per row shift. The minimum TDI shift time is the digitization time for one row. TDI cannot be done with cameras using interline CCDs, such as the U2000 and U4000.



Raman image and spectrum acquired using KestrelSpec™ software from Catalina Scientific (www.catalinasci.com)

ALTA® SERIES CAMERAS: FEATURES

ADVANCED COOLING

The Apogee cooling system has long been one of the most advanced in the industry. The Alta control system has been expanded to 12 bits, allowing a temperature control range of 213K to 313K (-60 to +40 C) with 0.024 degree resolution. Sensors have been added to monitor the heat sink temperature. A power indicator has been added to give the user an idea of how much drive is being given to the CCD cooler. The automatic back-off function is now handled by the firmware and driver. If the system cannot reach the desired temperature, the system automatically backs off to a point where regulation can be maintained, 2 degrees above the maximum temperature reached. The new set point is given to the user. Cooling deltas of 40-70C (depending on sensor area) are typical with simple air cooling.

For customers desiring heat dissipation away from the camera housing, Apogee offers liquid recirculation backs for most Alta cameras.

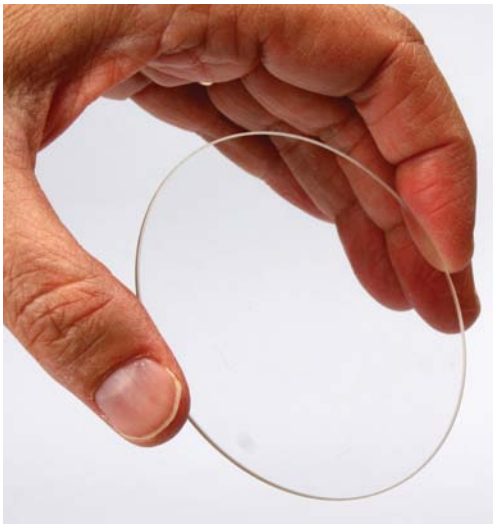
PROGRAMMABLE FANS

The fans for the Alta® systems were chosen for the absolute minimum vibration. In most environments, the movement of the fans will not be detectable when the cameras are attached to a microscope or telescope. However, for those customers with exceptionally demanding applications, Alta fans may be turned off, or run at reduced speeds while still maintaining adequate cooling. The optional liquid circulation headsinks may also be used to minimize vibration.

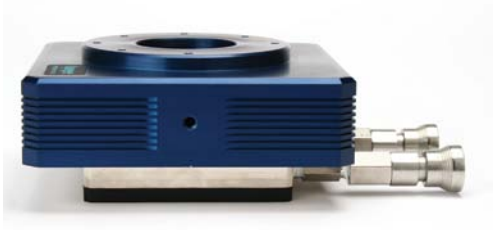
DUAL DIGITIZATION

With our fast USB2 systems, we offer dual digitization: high precision, low noise 16 bit performance as well as high speed 12 bit for focussing and other high frame rate needs. Digitization depth is selectable image by image in software

FUSED SILICA OPTICS



Apogee takes pride in professional grade details like fused silica windows with BBAR or magnesium-flouride coatings. We also offer custom windows, including wedge windows and customer supplied optics.



OPTIONAL LIQUID CIRCULATION

Apogee offers optional Alta liquid recirculation backplates as well as temperature-regulated liquid recirculators for customers wanting to remove heat dissipation from the area of the camera; wanting to house the camera inside an enclosure; or wanting supplemental cooling. The limitation: the temperature of the recirculating liquid must not go below the dew point.

D02 and D01 housings

HOUSING OPTIONS

Alta cameras with small format CCDs have a 0.69” (17.5 mm) C-mount back focal distance for direct interface to microscopes and C-mount lenses. Medium format sensors use the D02 housing with 2” thread. Large format sensors use the D07 housing with a 2.5” thread. Back focal distance for the D02 and D07 housing is approximately 1.04” (26.4 mm). All cameras have a bolt circle with metric threads for adaptation to a wide variety of flanges.

OPTIONAL WIDE ENTRANCE ANGLE HOUSINGS

Housings with wide entrance angles are available for most medium and large format CCDs. See the section on Housings for additional details.

OPTIONAL LOW PROFILE HOUSINGS

Lower profile housings are available for all Alta models to achieve <0.5” (<12.7mm) back focal distances without internal shutters.

DEEP COOLING

The Alta’s optional, deeper cooling housing, the D09, that provides cooling to as much as 70°C below ambient without liquid circulation. A wide variety of sensors are supported, including large format and spectroscopic format CCDs.

ALTA® SERIES CAMERAS: FEATURES

SHUTTERS

Apogee Imaging Systems uses the finest shutters available for our cameras from Vincent and Melles Griot. These shutters have been carefully integrated into our camera heads with minimum impact on back focal distance and camera size. These shutters have a huge advantage over simple rotating blade shutters in terms of light blockage and minimum exposure time.

Alta® cameras use three shutter types, depending on the aperture. Apogee shutters use lower voltage coils then those listed as standard by the shutter manufacturers, roughly 1/2 of the standard voltage requirement. The lower voltages extend the lifetimes of the shutters.
D01 housing, small format sensors:
Vincent Uniblitz 25mm Shutter
D02 housing, medium format sensors:
Melles Griot 43mm Shutter
D07 and D09 housings, large format sensors:
Melles Griot 63.5mm Shutter

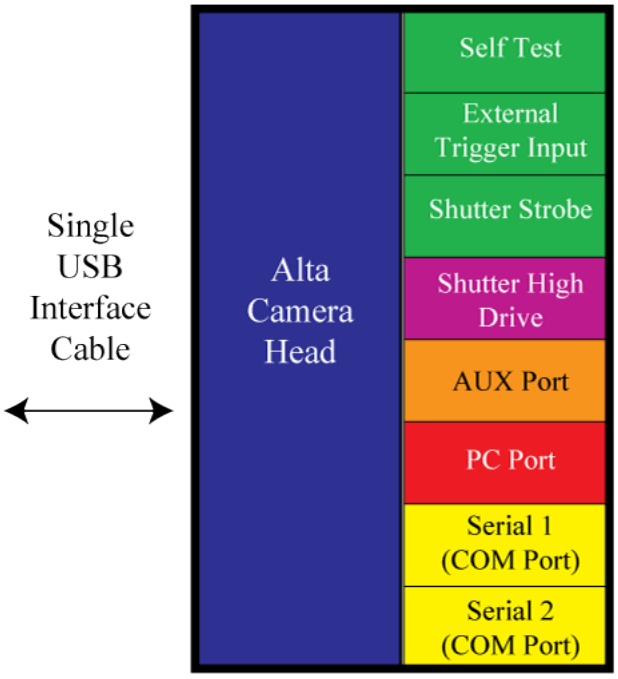
Full frame CCDs typically require an electromechanical shutter unless the light source is gated in some other way. Otherwise light falling on the sensor during the readout process corrupts the image. Interline CCDs shift the charge from the photodiode section of each pixel to the masked storage diode. For low light applications, the mask is sufficiently opaque to prevent smearing. However, in high light applications, interline CCDs require electromechanical shutters to prevent smearing during readout.

Specifications subject to change without notice.

www.ccd.com

GENERAL I/O PORT FOR ALTA & ASCENT

Our general purpose I/O port can tell you when the shutter is open, or can be used for a wide variety of external trigger inputs, including line-by-line control of TDI shifts.



RESIDUAL BULK IMAGES

Sometimes CCD images show very faint ghost images from previous bright images. These residual bulk images ("RBIs") are caused by trapped electrons, predominantly created at deeper depths by longer wavelengths. RBIs are created in proportion to incoming flux, and therefore are more obvious in those pixels that were very bright in previous images. RBIs are not created by blooming or excess charge in the pixels. RBIs cannot be "fixed" by adjustments to clocks or voltages. However, the "ghost image" effect can be minimized by uniformly filling these deep traps prior to acquiring an image. Some Alta systems, such as the U16M and U9000, include a programmable near-IR pre-flash system.

CABLE LENGTH

The USB2 specification limits cable length to 5 meters, with up to 5 hubs, for a total of 30m. However, there are USB1 and USB2 extenders available for operation up to 10 km. The USB1 extenders slow the transfer to a maximum of 500 kpixels per seoond. USB2 extenders are available using Cat5 cable or fiber optic cable.

SINGLE 12V POWER SUPPLY

Alta camera systems include a 12V international power supply (100V-240V input), but can be operated from a clean 12V source.

M51 courtesy Greg Morgan, U16M camera. The full image is at the image gallery at www.ccd.com.

CCD SELECTION

CCDs come in many shapes and sizes, as well as several different architectures. Some architectures were developed specifically to address the needs of extremely low light applications like astronomy (back-illuminated CCDs). Other technologies can be adapted to low light applications with excellent results, but a bit more patience and diligence may be necessary (interline transfer CCDs). Here are some ideas to keep in mind:

QUANTUM EFFICIENCY

Higher sensitivity = higher quantum efficiency = shorter exposures to get the same results. Shorter exposures = more time for other exposures. The peak value of a quantum effiiciency curve does not tell the full story of a CCD's sensitivity. The area under the curve gives the true comparison of a CCD's relative sensitivity. Twice the area under the curve = half the time making the exposure. Or, use the same exposure time, but get twice the signal. Apogee supports front-illuminated, back-illuminated, and interline transfer devices. Back-illuminated CCDs have the highest overall sensitivity. However, they are subject to etaloning (see below) in the near-infrared, especially at longer wavelengths. Front-illuminated CCDs are much less expensive than back-illuminated CCDs and are not subject to etaloning. Interline transfer CCDs can take extremely short exposures, but have the lower sensivity and dynamic range than full frame CCDs.

UV & NIR WAVELENGTHS: RECOMMENDATIONS

Between 200-400 nm, the highest quantum efficiency is found in back-illuminated UV enhanced CCDs such as from e2v and Hamamatsu. Most Kodak CCDs have zero QE at 300 nm, increasing linearly to >40% at 400 nm.

Back-illuminated CCDs have the highest QE in the near infrared (NIR), but they are also subject to etaloning (also known as "fringing"). Simply put, the long wavelengths bounce around inside the CCD itself. Some companies have developed proprietary versions of CCDs that minimize, though not eliminate, the effect.

PIXEL SIZE

Normally larger pixels have higher full well capacities than smaller ones. Higher full well capacities increase the potential maximum signal. If readout noise is kept low, higher signal means a higher signal-to-noise ratio (SNR), which is what allows us to see faint detail without flat-lining the bright spots. High SNR pulls those faint, wispy arms out of a spiral galaxy without making the center into a burned white blob. High SNR can also detect very small changes on top of a deep background, i.e. the stuff that makes discoveries. Get the largest pixel that matches your optics. Need help making the match? Give us a call.

INTERLINE TRANSFER CCDs

Interline transfer CCDs, up to the scale of 35mm film, have inherent anti-blooming, but less dynamic range and lower quantum efficiency than Kodak's other front-illuminated offerings. Interlines also have high dark current in the storage diodes, as well as some leakage through the storage diode masks. Mass markets for interline CCDs mean much lower prices per pixel, and a great entry point into professional level imaging.

Because interline CCDs shutter the exposure by shifting the charge from the photodiode section of the pixel to the storage diode of the pixel, exposure times can be as short as a few microseconds. Time between exposures is determined by the time required to read out the entire CCD, which varies from camera to camera.

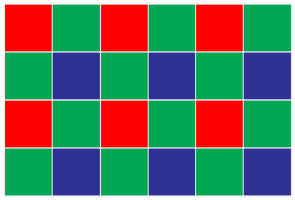
Interline transfer CCDs cannot do time-delayed integration (also known as "drift scan" mode) because charge is not transferred from photodiode to photodiode, but rather into the masked storage diode.

DARK CURRENT

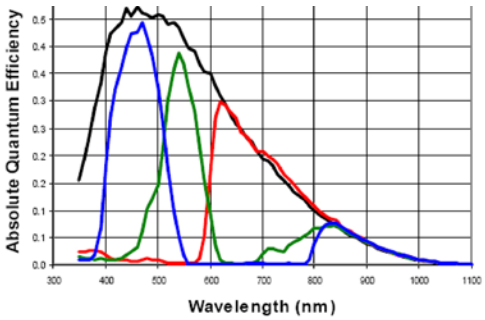
Thermally generated signal, or dark current, is not noise. The shot noise component of the dark current is one element of noise, which is the square root of the dark current. You can correct for the dark current itself if you can measure it, which requires the camera's cooling to be programmable and stable. The deeper the cooling, the less correction you're going to have to do.

COLOR CCDS

Color CCDs are convenient for one-shot color, but they compromise in several ways. First, the typical red-green-blue (RGB) Bayer pattern over the pixels of the CCD (see below) cannot be changed--you cannot do monochromatic imaging one day, RGB the next, and cyan-magenta-yellow (CMY) on the third. Second, color CCDs cannot deliver the full resolution of the imager. They can, however, deliver all three color channels at exactly the same instant in time.



Typical RGB Bayer filter pattern designed to mimic the responsivity of the human eye.



Quantum efficiency of the Kodak KAI-16000 CCD: black line is monomchrome version; RGB lines are the color version.

DYNAMIC RANGE

Interline transfer CCDs have, at most, a full well capacity of about 50K electrons. If the electronics limits the read noise to 8-10 electrons, this is a dynamic range of 50K/10 = 5000:1, or about 12.3 bits. Most argue for oversampling by an extra bit, or some argue even two. However, a 16-bit analog-to-digital (AtoD) converter does not upgrade a 12 bit imager into a 16 bit imager. A Kodak KAF-0261E CCD in an Alta U260 camera, using the high dynamic range output amplifier, can be operated at 16 electrons noise RMS with a full well of 500K electrons, or a dynamic range of more than 30K:1, about 15 bits (90 dB).

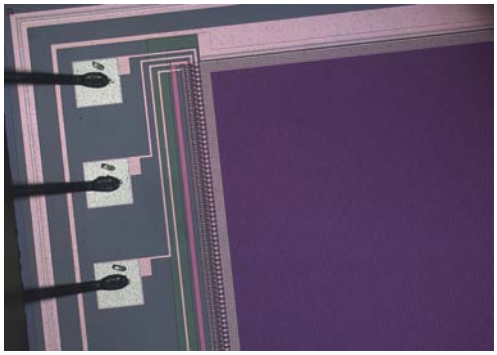
CCD SELECTION

CCD GRADES

Each manufacturer's specification sheet for an imager defines the cosmetic grades for that specific imager. Different manufacturers use different procedures; a grade 1 of Imager A may allow column defects, but a grade 2 (lower grade) of Imager B may not. Kodak usually grades their CCDs at about 25°C, and most of their defects disappear in cooled cameras when the images are flat-fielded. In most cases, you cannot see the difference between the grades. Other companies, such as e2v, grade their CCDs at low temperatures, so their defects are less likely to disappear when the CCD is cooled.

Defects on CCDs do not grow or move over time. They are mappable. Lower grade CCDs do not wear out faster. Most lower grade Kodak CCDs no longer allow column defects. These lower priced CCDs are excellent bargains.

Please check the manufacturers' data sheets for each CCD carefully before purchasing a system. Some large format CCDs allow several column defects in the "standard grade" CCD, If you have trouble finding or understanding their cosmetic gradings, please ask us for help.



Close-up of legacy Kodak KAF-1602 CCD

E2V CCDs: AIMO & NIMO

E2V's AIMO (Advanced I Metal Oxide, aka MPP) CCDs have hundreds of times less dark current than non-IMO (NIMO) CCDs. Some variations of their CCDs, such as the enhanced UV response CCD42-40 found in the U42-UV camera, are only available as NIMO devices.

ANTI-BLOOMING

Anti-blooming (AB) bleeds off excess charge from individual pixels so that it does not spill over into neighboring pixels, causing a white stripe down the column. For applications like astrophotography, AB preserves the aesthetics of the image. For photometric applications, AB can be used if exposure times are carefully controlled to avoid excess charge. In the past, AB drastically lowered full well capacity and quantum efficiency. Newer Kodak CCDs have anti-blooming with higher quantum efficiency and full well capacities.

TYPICAL PERFORMANCE

CCD manufacturers specify their sensors in terms of typical performance and worst performance. For example, a specification sheet may say "15 electrons noise typical, maximum 20 electrons noise." Such a CCD with 18 electrons noise may be noisier than "normal", but it does meet the manufacturer's specification and cannot be returned to the manufacturer. Asking the CCD manufacturer to guarantee a "typical" value can increase the price of the CCD by a factor of 3-4X. Apogee's published prices are based on unsorted CCDs that meet the manufacturer's specifications for the grade ordered.

Please note that CCD manufacturer's test conditions may not be representative of performance in an Apogee camera. e2v, for example, normally tests readout noise at 20 kHz, much slower than the 700 kHz readout of an Alta camera in 16 bit mode.

Alta U16M camera with fiber optically bonded CCD

KODAK BLUE PLUS CCDs

CCDs create charge due to the photoelectric effect. In order to create an image rather than random electricity, the charge must be held where it was created. "Traditional" CCDs use from one to four polysilicon gates to carry a voltage that traps the charge until transferred. Polysilicon has limited transmissivity. Indium tin oxide (ITO) gates have higher transmissivity, but lower charge transfer efficiency. Kodak's combination of one polysilicon gate and one ITO gate is marketed as Blue Plus (because of the increase in blue sensitivity). The overall sensitivity of Blue Plus CCDs is much higher than multi-phase front-illuminated CCDs using only polysilicon gates. However, when researching point sources of light, it is good to keep in mind that there is a marked increase in quantum effiiency on the ITO side of each pixel. (See MICROLENSES below).

MICROLENSED CCDs

Many CCDs now use microlenses over each pixel. In the case of interline transfer CCDs, the microlenses focus the light onto the photodiode. In the case of Kodak's Blue Plus CCDs (see above), the microlenses focus the light onto the ITO gate side of the pixel. Microlenses greatly improve overall quantum efficiency, but introduce some angular dependency. Fill factor is normally less than 100%. See data sheets for individual CCDs for details.

FIBER OPTIC BONDING

Apogee now offers fiber optically bonded versions of the Alta cameras. Pictured to the left is a U16M camera with a fiber attached to the CCD. Applications for bonding including radiology, transmission electron microscopy, x-ray crystallography, and gated image intensifiers. Please contact us with your requirements.

ALTA® Full-Frame Front-Illuminated CCDs: Supported CCDs

Alta® Series cameras with a USB2 interface use a U prefix, for example, U42. This page lists the U Series systems available with front-illuminated CCDs. For listings of back-illuminated CCDs, interline transfer CCDs, and spectroscopic format CCDs, see the following pages.

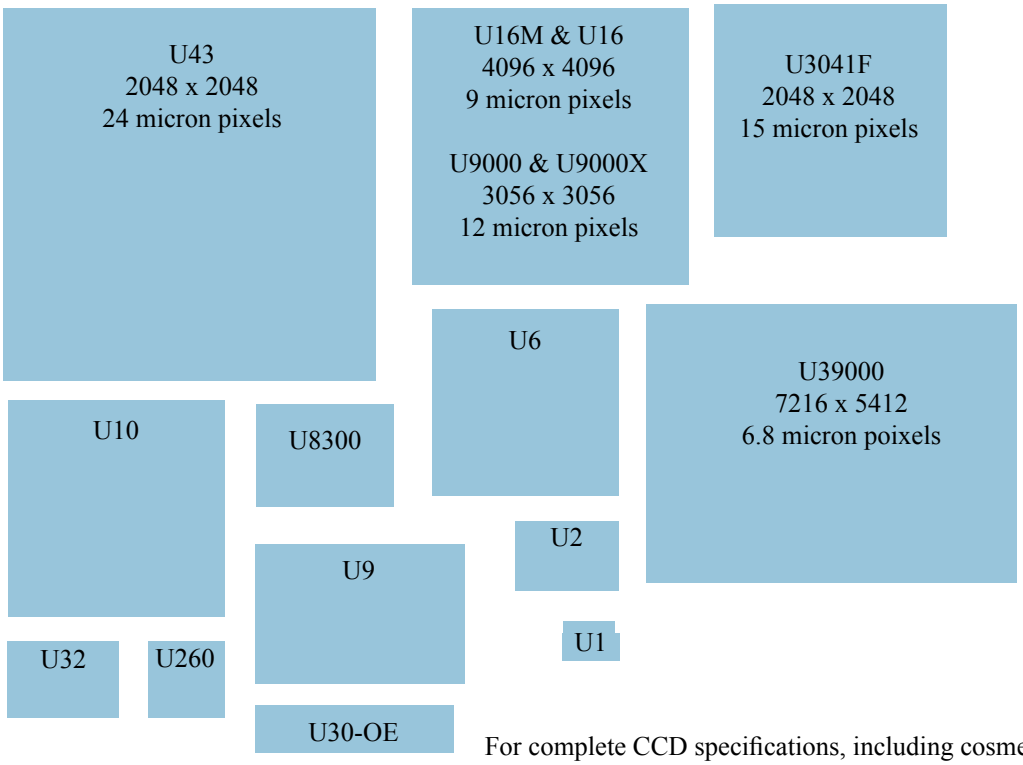
CCD ARRAY SIZES

Camera Model	Kodak CCD*	Array Size		Total Pixels	Pixel Size (µ)	Array size (mm)		Imaging Area (mm2)	Diagonal (mm)	Video Imager Size	Mono=M Color=C
						X	Y				
U39000	KAF-39000	7216	5412	39052992	6.8	49.1	36.8	1805	61.3	3.83”	M,C
U16	KAF-16801E	4096	4096	16777216	9	36.9	36.9	1359.0	52.1	3.3”	M
U16M	KAF-16803	4096	4096	16777216	9	36.9	36.9	1359.0	52.1	3.3”	M
U9000	KAF-09000	3058	3058	9351364	12	36.7	36.7	1346.6	51.9	3.2”	M
U8300	KAF-8300E or CE	3448	2574	8875152	5.4	18.6	13.9	259	23.2	1.4”	M,C
U9	KAF-6303E	3072	2048	6291456	9	27.6	18.4	509.6	33.2	2.1”	M
U43	KAF-4320E	2048	2048	4194304	24	49.1	49.1	2415	69.5	4.3”	M
U3041F	Fairchild CCD3041	2048	2048	4194304	15	30.7	30.7	943.7	43.3	2.7”	M
U10	e2v TH7899*	2048	2048	4194304	14	28.7	28.7	822.1	40.6	2.5”	M
U32	KAF-3200	2184	1472	3214848	6.8	14.9	10.0	148.7	17.9	1.1”	M
U2	KAF-1603ME	1536	1024	1572864	9	13.8	9.2	127.4	16.6	1.0”	M
U6	KAF-1001E	1024	1024	1048576	24	24.6	24.6	604.0	34.8	2.2”	M
U1	KAF-0402ME	768	512	393216	9	6.9	4.6	31.9	8.3	0.5”	M
U30-OE	e2v CCD30-11	1024	256	262144	26	26.6	6.7	177.2	27.4	1.7”	M
U260	KAF-0261E	512	512	262144	20	10.2	10.2	104.9	14.5	0.9”	M

*The U10 uses an e2v (formerly Atmel, formerly Thomson) TH7899 CCD.

FRONT ILLUMINATED CCDs

Imaging Area of CCD



Horsehead Nebula (NGC 2023) by Ken Crawford, U9000 camera (full image in the gallery at www.ccd.com)

For complete CCD specifications, including cosmetic grading, see data sheet from manufacturer.

ALTA® Full-Frame Front-Illuminated CCDs: Specifications

Most of the CCDs are offered in several different housings: standard, low profile, wide angle, and high cooling. For details, see the following section regarding housings.

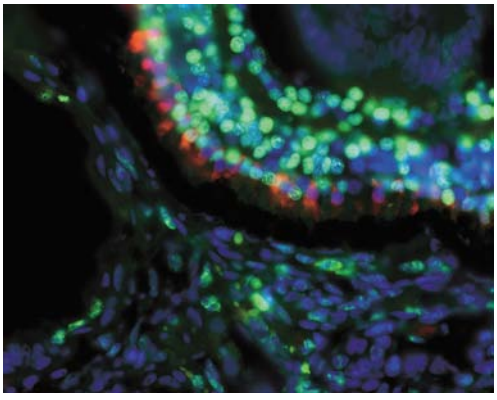
TYPICAL PERFORMANCE

Camera Model	Linear Full Well (typical)	Dyn. Range (dB)	QE@ 400nm	Peak QE	Anti-Bloom-ing	Read Noise (typ.)[1]	Cooling[2] (ΔC)	Dark Current[2] (Typical)	Cooling[3] (ΔC)	Deep Cooling Dark Current[3] (Typical)
U39000	60K	71	18%	32%	NA	16 e-	50	0.03 e/p/s	NA	NA
U16	100K e-	81	31%	69%	NA	9 e-	40	0.3 e/p/s	60	0.04 e/p/s
U16M	85K e-	79	41%	60%	>100X	9 e-	40	0.2 e/p/s	60	0.03 e/p/s
U9000	110K e-	82	37%	64%	>100X	9 e-[4]	40	0.3 e/p/s	60	0.04 e/p/s
U8300	25.5K e-	70	38%[5]	56%[5]	1000X	9 e-	50	0.02 e/p/s	70	0.002 e/p/s
U9	100K e-	79	30%	67%	NA	11 e-	45	0.3 e/p/s	65	0.04 e/p/s
U43	500K e-	88	39%	72%	NA	12 e-	50	2 e/p/s	NA	NA
U3041F	100K e-	82	3%	43%	NA	10 e-	40	1 e/p/s	NA	NA
U10	150K e-	78	0.5%	38%	NA	19 e-	40	0.8 e/p/s	NA	NA
U32	55K e-	77	53%	86%	NA	8 e-	50	0.08 e/p/s	NA	NA
U2	100K e-	78	44%	82%	NA	12 e-	50	0.2 e/p/s	NA	NA
U6	HG:200K e-[6]	87	39%	72%	NA	9 e-[6]	45	0.4 e/p/s	65	.05 e/p/s
U1	100K e-	79	53%	85%	NA	11 e-	50	0.1 e/p/s	NA	NA
U30-OE	300K e-	84	24%	59%	NA	20 e-	50	0.2 e/p/s	70	0.02 e/p/s
U260	HG: 200K e-[6]	86[6]	29%	65%	NA	10 e-[6]	50	0.2 e/p/s	NA	NA

Notes:
1. Read noise in 16 bit mode. Noise in 12 bit mode is typically 2 counts.
2. Cooling with standard, low profile, or wide angle housing.
3. Cooling with high cooling housing (D09).
4. Read noise for U9000X in 16 bit mode is typically 12 e-.
5. Quantum efficiency (QE) for monochrome version of CCD. See QE curves regarding color version of CCD.
6. The CCDs in the U6 and U260 have two output amplifiers: high gain (for low noise) and low gain (for high dynamic range). One amplifier must be chosen at the time the camera is manufactured. Full well capacity for the U6 and U260 using the high gain amplifier is about 200K e-; in low gain, about 500K e-. Read noise for low gain is typically 22 e- for the U6 or 16 e- for the U260. Dynamic range for the U260 in LG mode is about 90 dB.

D07F Housing for U16, U16M, U9000, and U16000

Image courtesy Dr. David Rapaport, UCSD



ALTA® Back-Illuminated & Interline Transfer CCDs: Supported CCDs

Alta® Series cameras with a USB2 interface use a U prefix, for example, U42. See previous pages for full frame front illuminated CCDs.

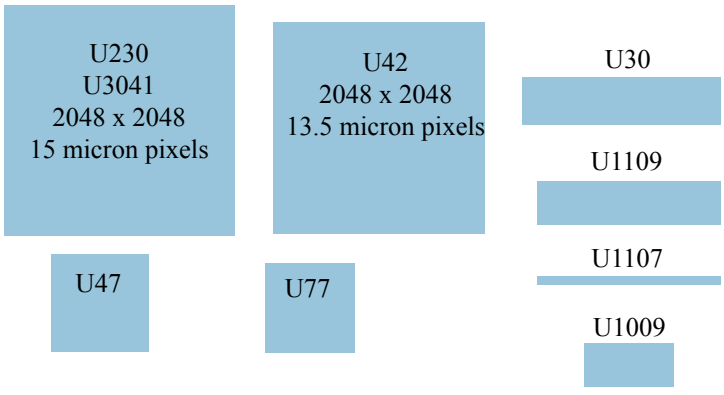
CCD ARRAY SIZES

Camera Model	CCD	Array Size		Total Pixels	Pixel Size (µ)	Array size (mm)		Imaging Area (mm2)	Diagonal (mm)	Video Imager Size	Mono=M Color=C
						X	Y				
Back-illuminated CCDs											
U42	e2v CCD42-40	2048	2048	4194304	13.5	27.6	27.6	764	39.1	2.4	M
U42-UV	e2v CCD42-40	2048	2048	4194304	13.5	27.6	27.6	764	39.1	2.4	M
U230	e2v CCD230-42	2048	2048	4194304	15	30.7	30.7	944	43.4	2.7	M
U3041	Fairchild 3041	2048	2048	4194304	15	30.7	30.7	944	43.4	2.7	M
U47	e2v CCD47-10	1024	1024	1048576	13	13.3	13.3	177	18.8	1.2	M
U77	e2v CCD77-00	512	512	262144	24	12.3	12.3	151	17.4	1.1	M
U30	e2v CCD30-11	1024	256	262144	26	26.6	6.6	177	27.4	1.7	M
U1109	Hama. S10140-1109	2048	506	1036288	12	24.6	6.1	149	25.3	1.6	M
U1107	Hama. S10140-1107	2048	122	249856	12	24.6	1.5	36	24.6	1.5	M
U1009	Hama. S10140-1009	1024	506	518144	12	12.3	6.1	75	13.7	0.9	M
Interline Transfer CCDs											
U16000	Kodak KAI-16000	4096	4096	16777216	7.4	36	24	866	43.3	3.3	M, C
U4000	Kodak KAI-04022	2048	2048	4194304	7.4	15.2	15.2	230	21.4	1.3	M, C
U2000	Kodak KAI-2020	1600	1200	1920000	7.4	11.8	8.9	105	14.8	0.9	M, C

For complete CCD specifications, including cosmetic grading, see data sheet from manufacturer.

BACK ILLUMINATED CCDs

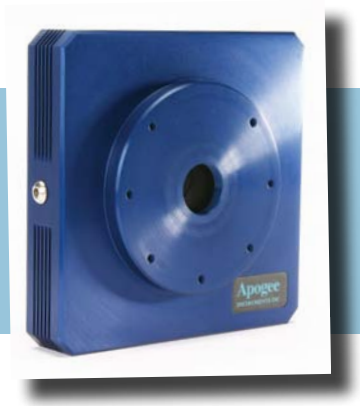
Imaging Area of CCD



INTERLINE TRANSFER CCDs

(available with monochrome or color CCDs)

D09L Housing with optional LR001 Liquid Recirculation Unit



D01 Housing

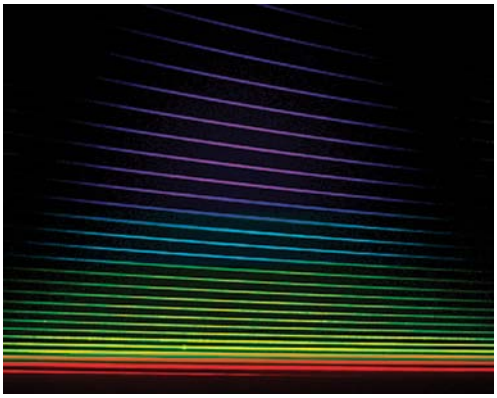
ALTA® Back-Illuminated & Interline Transfer CCDs: Specifications

Most of the CCDs are offered in several different housings: standard, low profile, wide angle, and high cooling. For details, see the following section regarding housings.

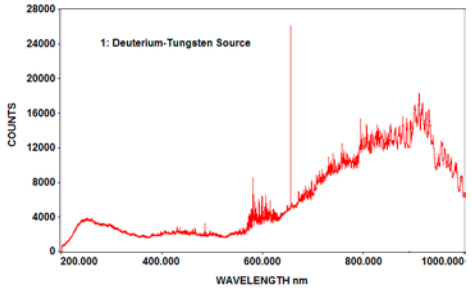
TYPICAL PERFORMANCE

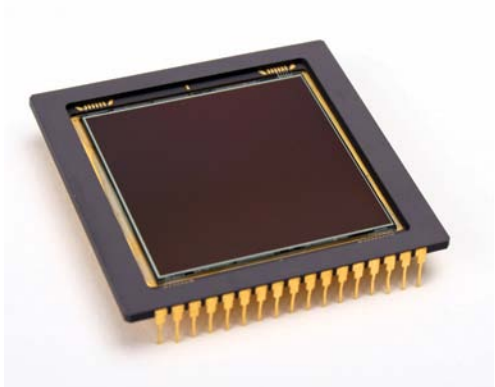
Camera Model	Linear Full Well (typical)	Dyn. Range (dB)	QE@ 400nm	Peak QE	Anti-Bloom-ing	Read Noise (typ.)[1]	Cool-ing[2] (ΔC)	Dark Current[2] (Typical)	Cooling[3] (ΔC)	Deep Cooling Dark Current[3] (eps)
Back-illuminated CCDs										
U42	100K e-	80	55%	96%	NA	10 e-	40	0.9 e/p/s	60	0.1 e/p/s
U42-UV	150K e-	84	57%	65%	NA	10 e-	40	400 e/p/s	60	35 e/p/s
U230	150K e-	85	55%	96%	NA	12 e-	40	0.4 e/p/s	60	0.04 e/p/s
U3041	100K e-	82	74%	96%	NA	10 e-	40	2 e/p/s	60	0.3 e/p/s
U47	100K e-	81	55%	96%	NA	9 e-	50	0.4 e/p/s	70	0.04 e/p/s
U77	350K e-	89	55%	96%	NA	12 e-	50	0.6 e/p/s	70	0.06 e/p/s
U30	500K e-	88	55%	96%	NA	21 e-	50	0.5 e/p/s	70	0.05 e/p/s
U1109	75K e-	71	58%	89%	NA	20 e-	50	2.2 e/p/s	70	0.2 e/p/s
U1107	75K e-	71	58%	89%	NA	20 e-	50	2.2 e/p/s	70	0.2 e/p/s
U1009	75K e-	71	58%	89%	NA	20 e-	50	2.2 e/p/s	70	0.2 e/p/s
Interline Transfer CCDs										
U16000	30K e-	73	39%	48%	300X	7 e-	40	0.2 e/p/s	60	0.02 e/p/s
U4000	40K e-	75	44%	55%	300X	7 e-	54	0.3 e/p/s	75	0.03 e/p/s
U2000	40K e-	75	47%	56%	300X	7 e-	54	0.4 e/p/s	75	0.04 e/p/s

Notes:
1. Read noise in 16 bit mode. Noise in 12 bit mode is typically 2 counts.
2. Cooling with standard, low profile, or wide angle housing (Fan / Liquid Circulation).
3. Cooling with high cooling housing (Fan / Liquid Circulation).
4. Quantum efficiency (QE) for monochrome version of CCD. See QE curves regarding color version of CCD.



Above: Echelle spectrograph image from deuterium-tungsten source (UV at top). Below: linearized spectrum created from the image, generated by linking the multiple orders together. Echelle spectrographs offer much higher sampling resolution by taking advantage of the area of imaging CCDs.





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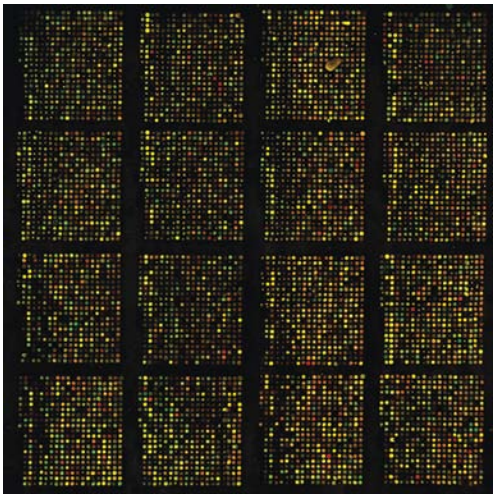
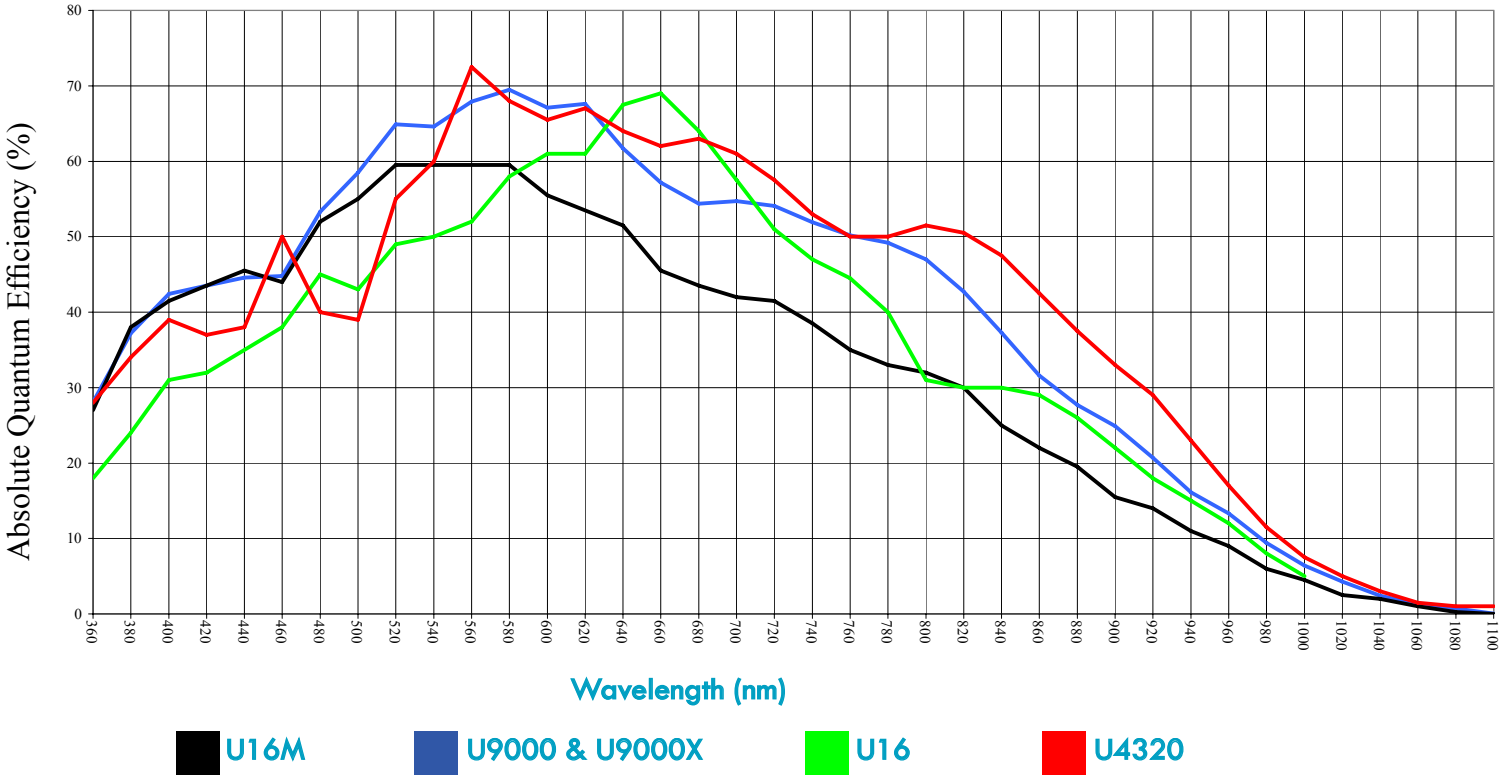
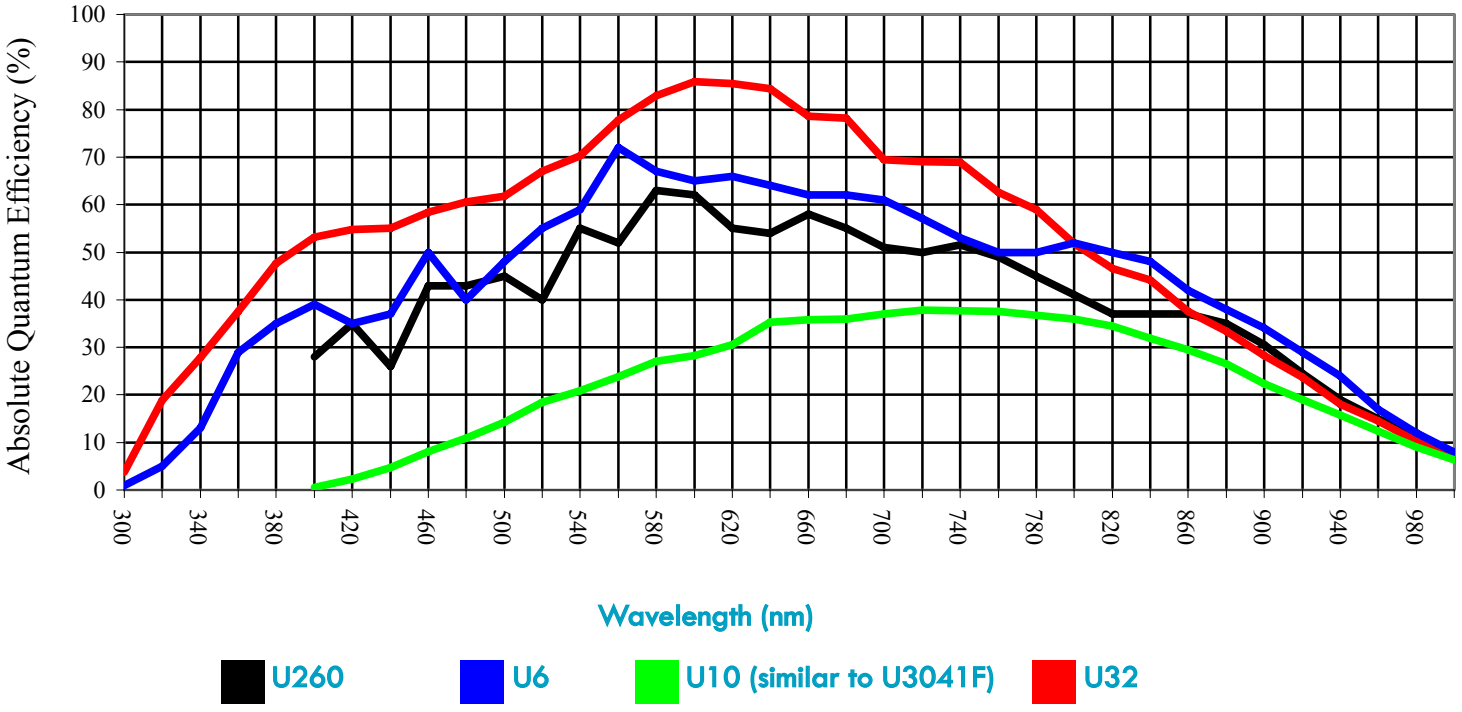


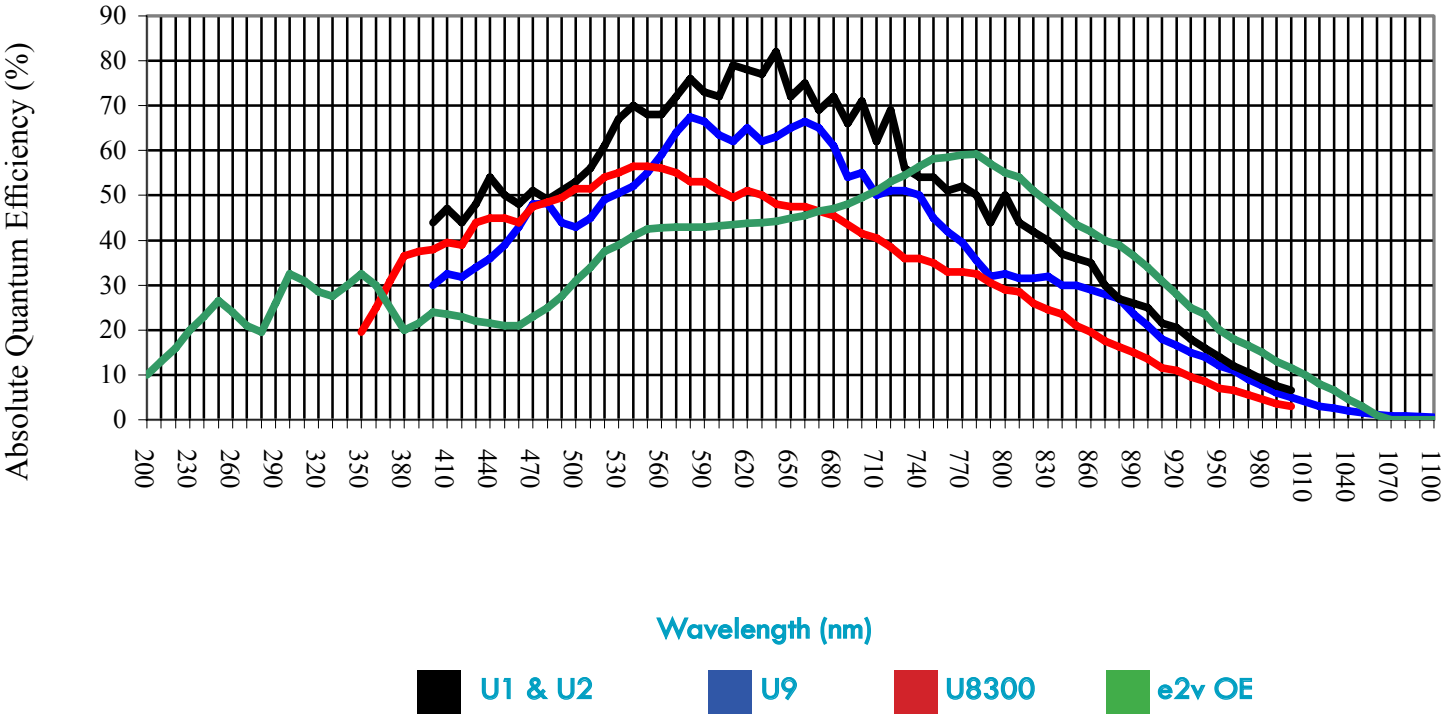
Interline transfer CCDs are the most popular choice for imaging of microtitre plates.

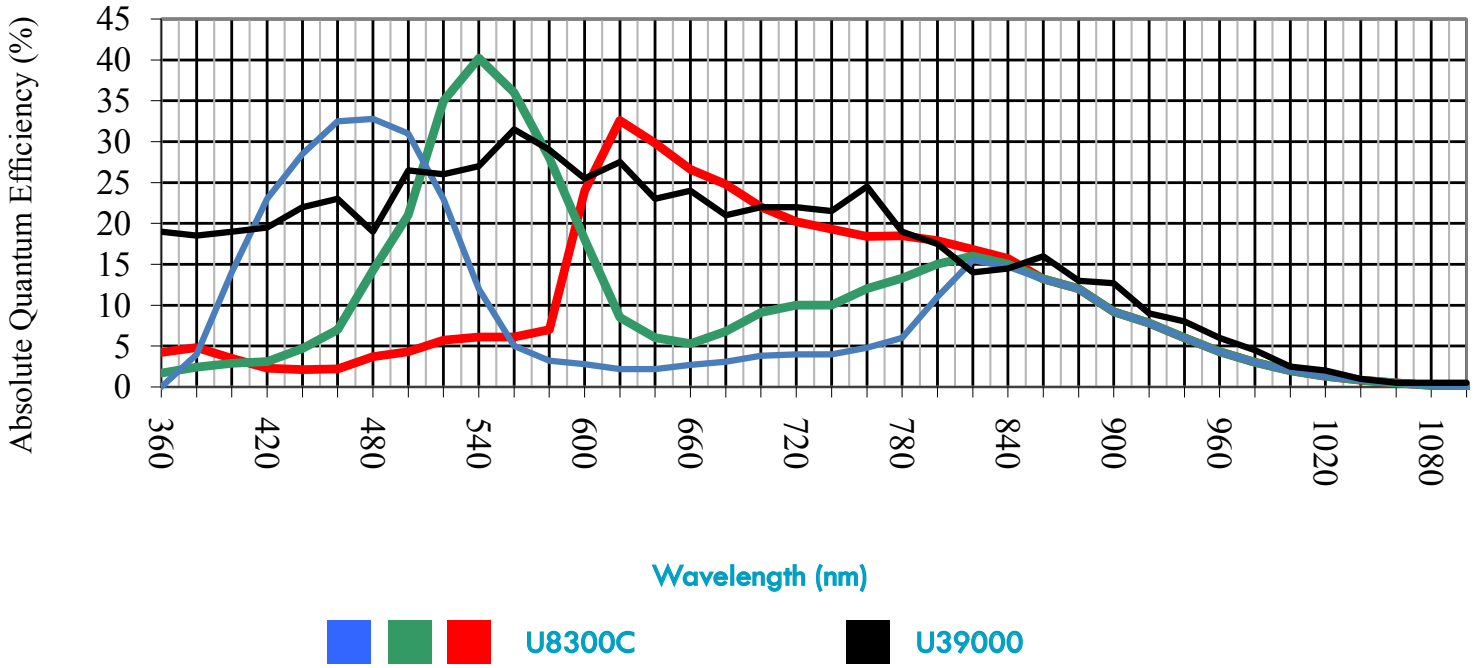
ALTA® Full-Frame Front-Illuminated CCDs: Quantum Efficiency



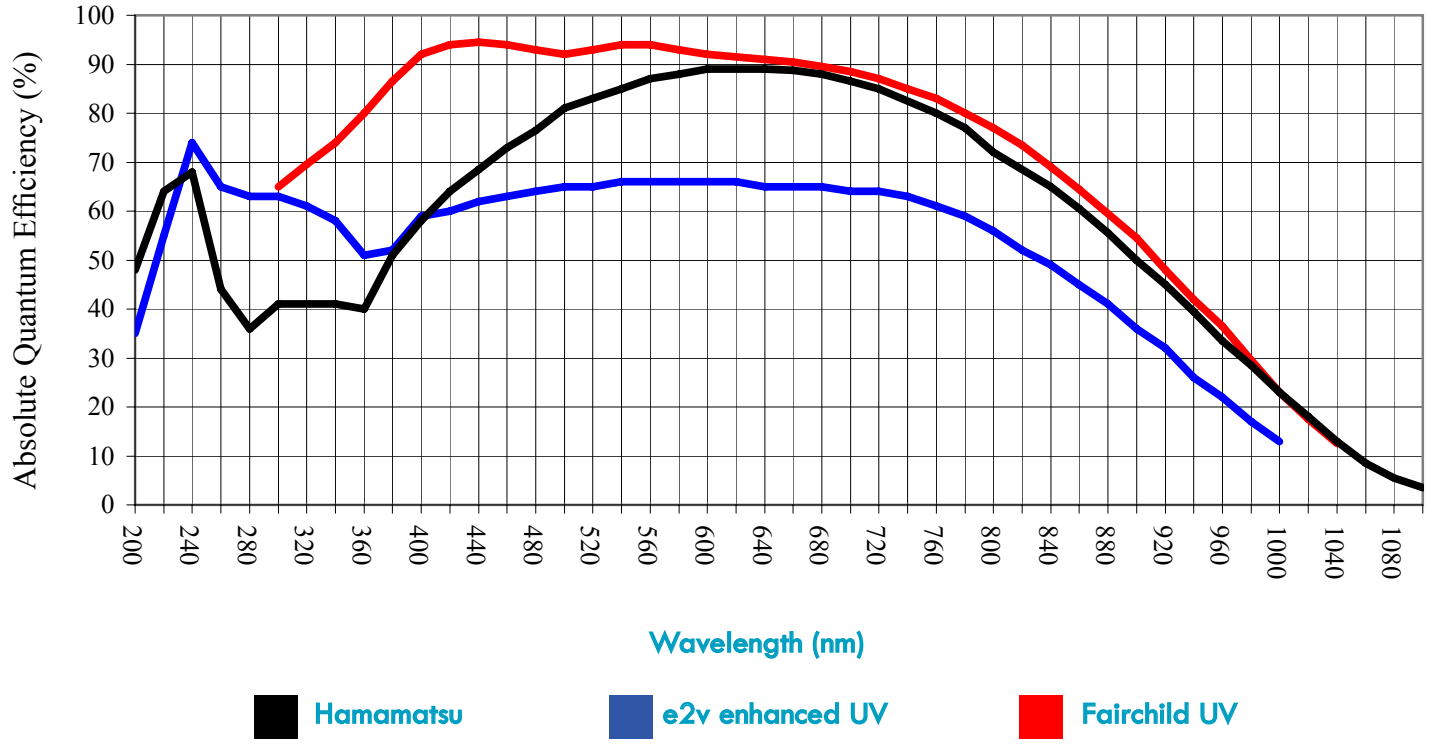


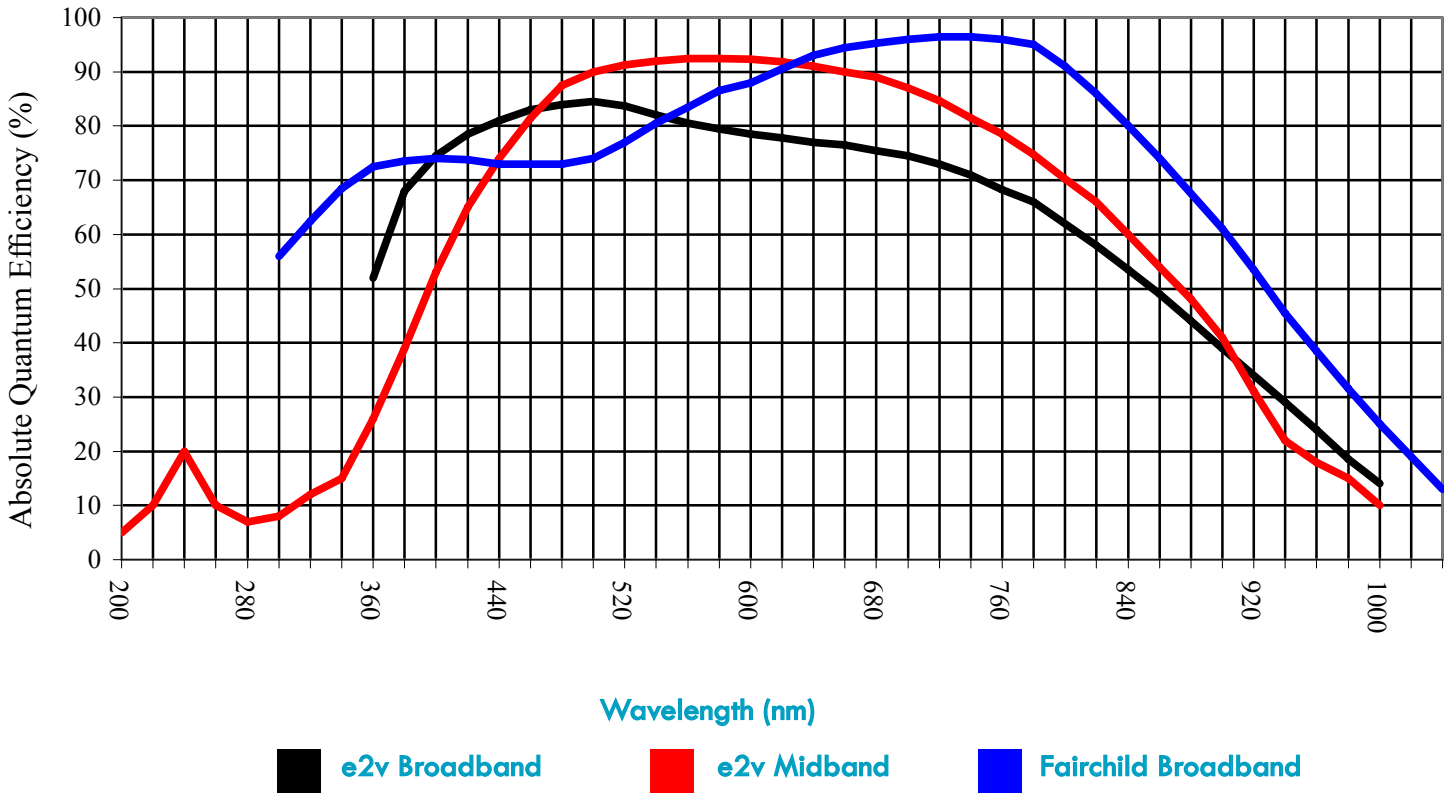
ALTA® Full-Frame Front-Illuminated CCDs: Quantum Efficiency



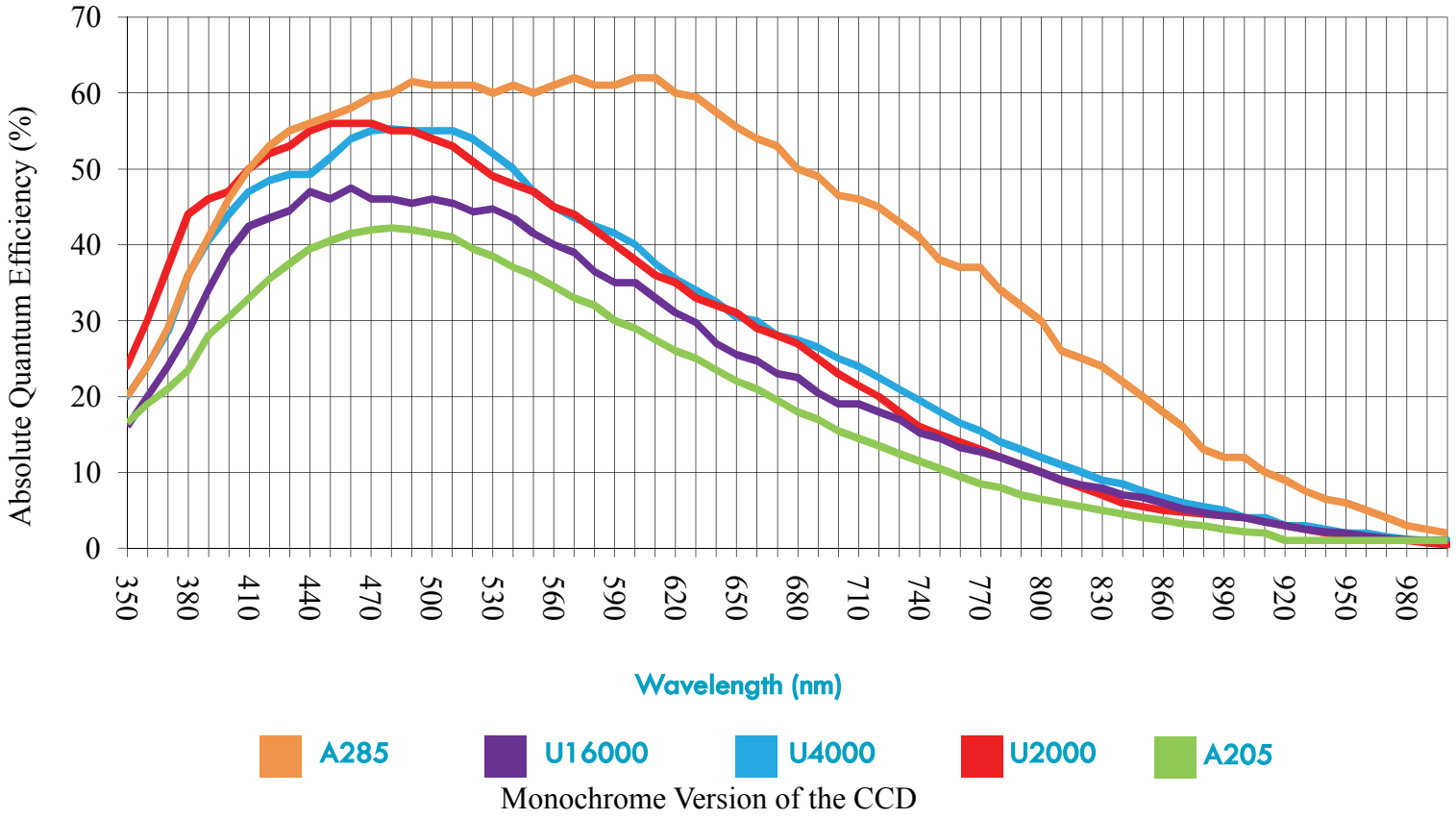


ALTA® Back-Illuminated CCDs: Quantum Efficiency

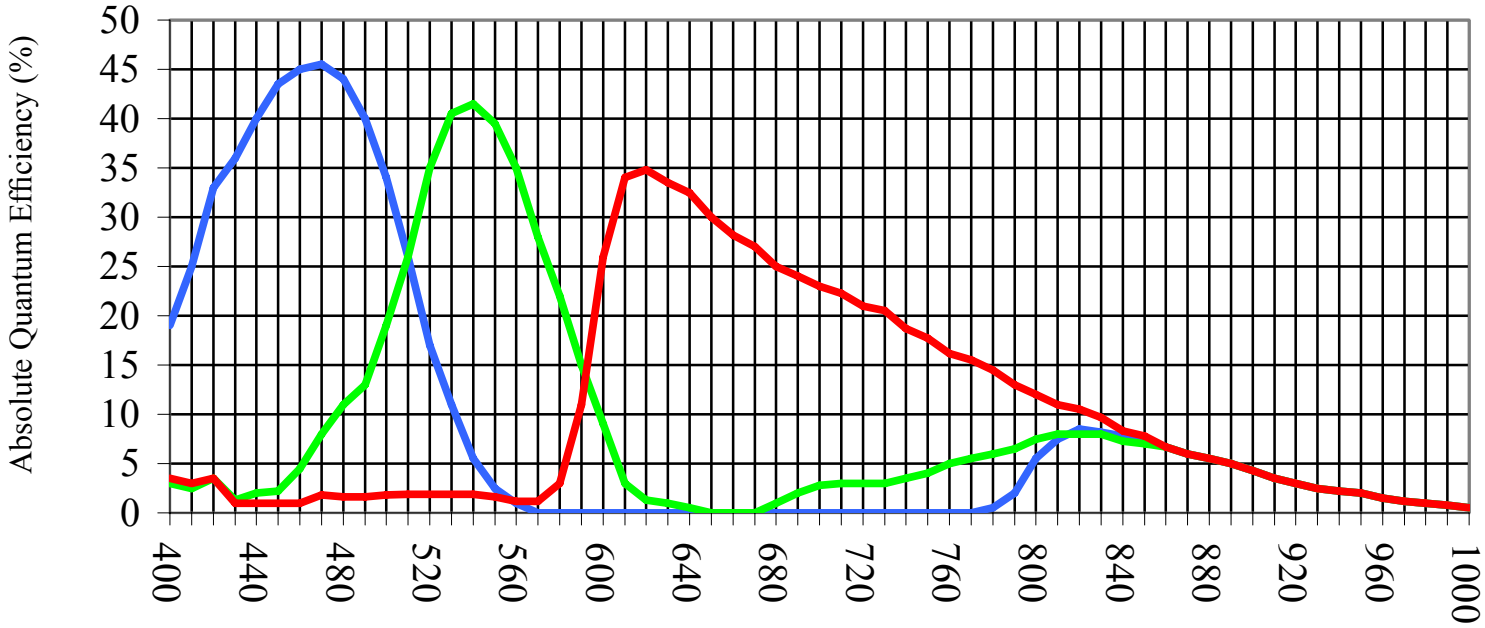




ALTA® / Ascent® Interline Transfer CCDs: Quantum Efficiency



Monochrome Version of the CCD

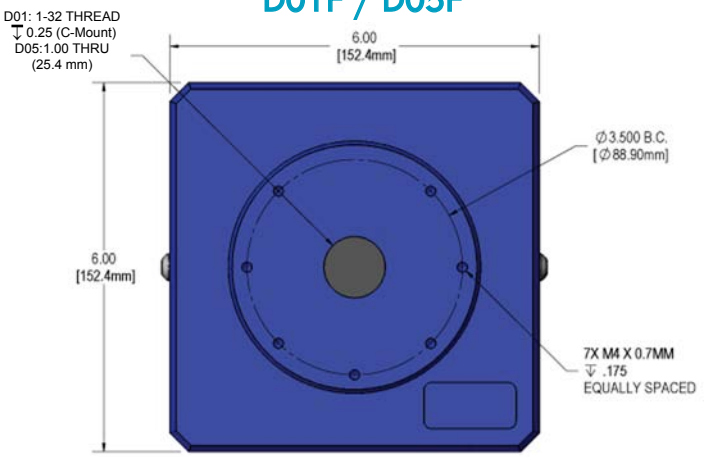


U16000, U4000, & U2000 Color

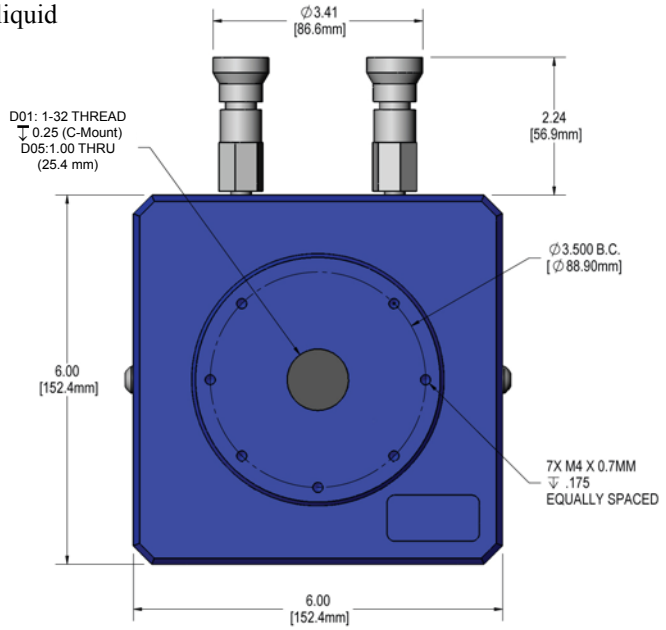
ALTA® Housings: D01 / D05 Low Profile

The D01 housing has a C-mount thread and C-mount back focal distance. D05 is the low profile variant with no internal shutter. F versions use fans; L versions use liquid circulation.

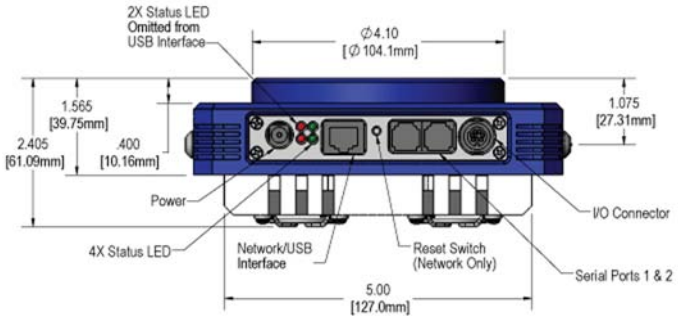
D01F / D05F



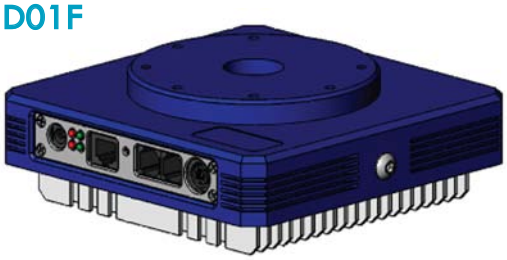
D01L / D05L



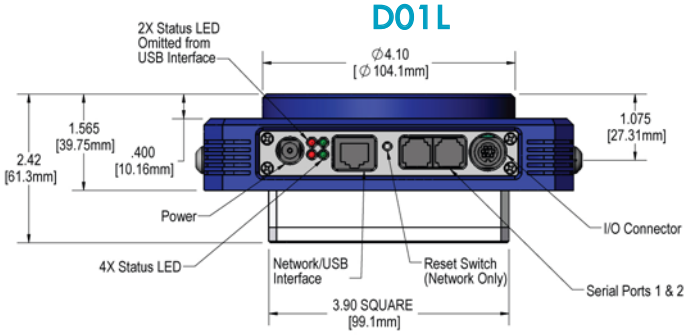
D01F



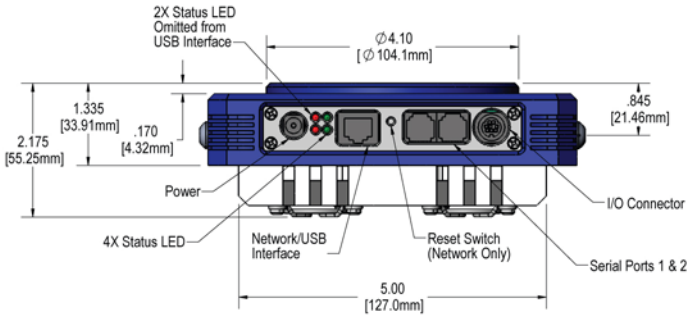
D01F



D01L

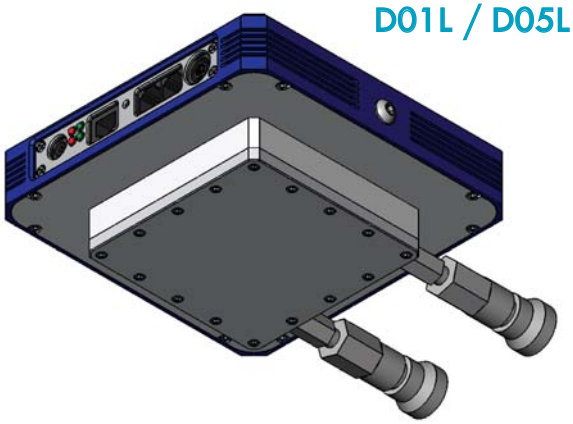


D05F (Low Profile)



D01F

D01L / D05L

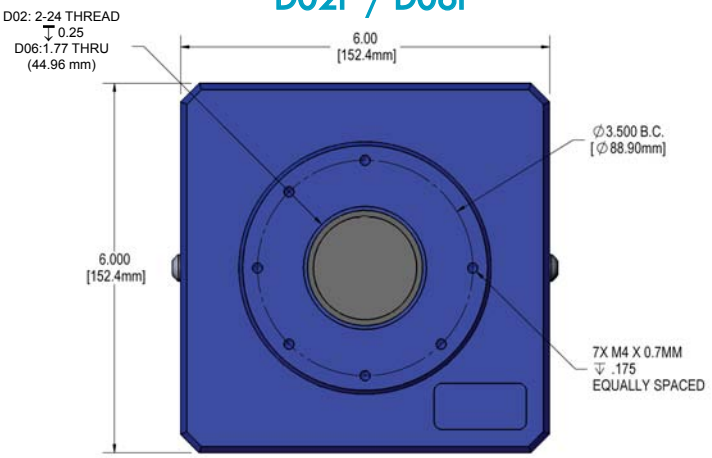


Drawings intended for illustration purposes only. For current mechanical details, please see www.ccd.com/alta_mechanical.html

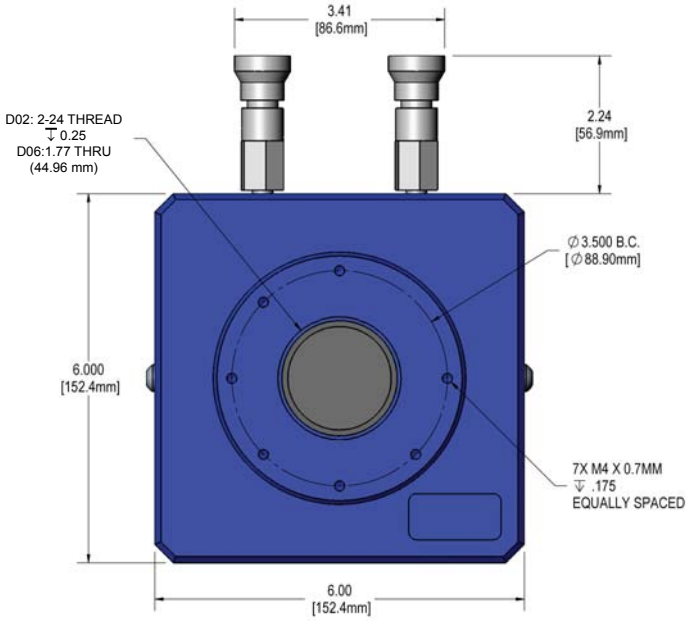
ALTA® Housings: D02 / D06 Low Profile

The D02 housing has a 2” thread. D06 is the low profile variant with no internal shutter.

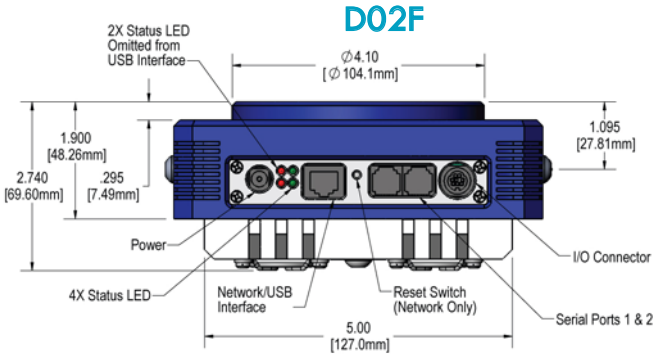
D02F / D06F



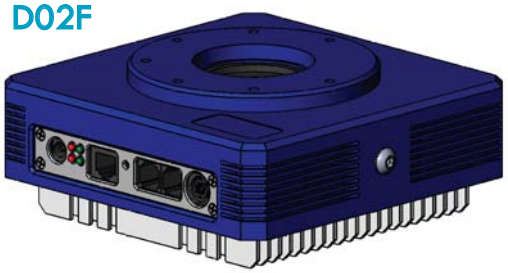
D02L / D06L



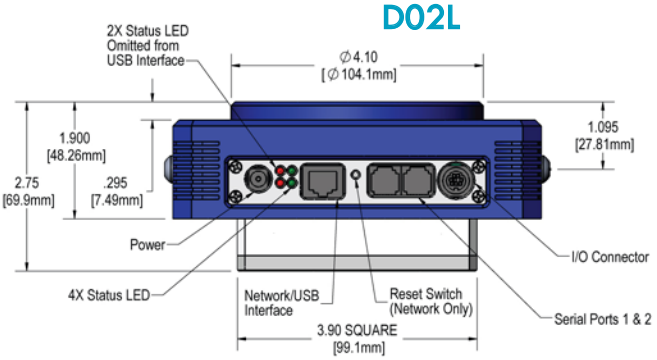
D02F



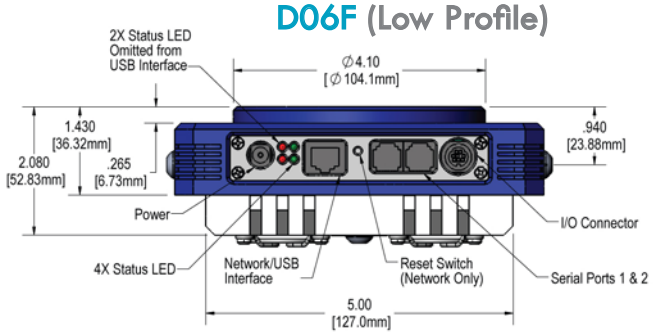
D02F



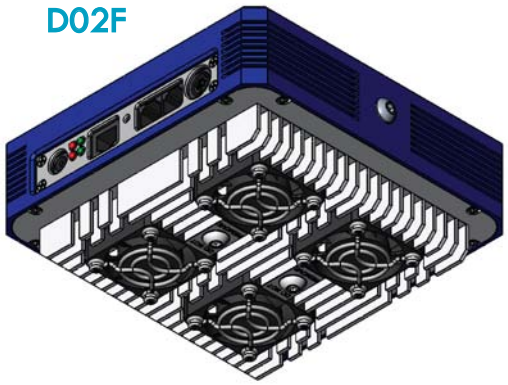
D02L



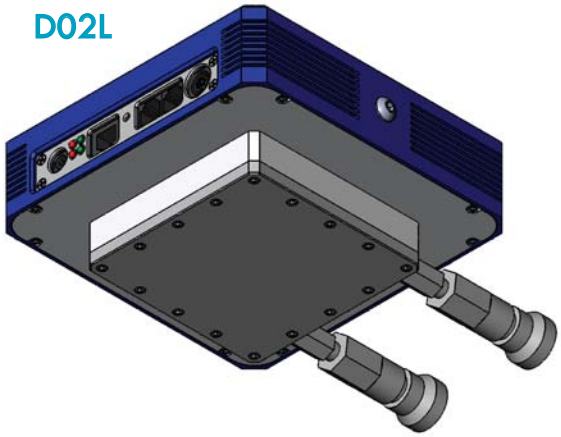
D06F (Low Profile)



D02F

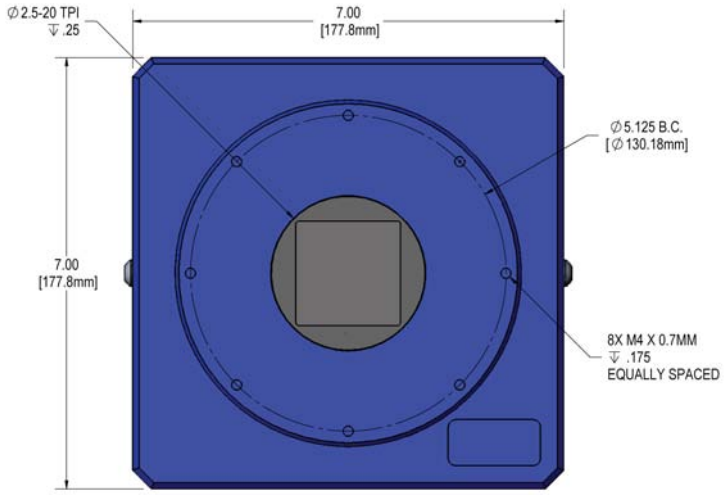


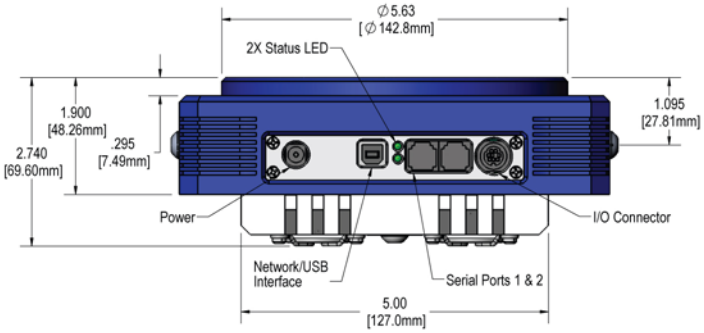
D02L

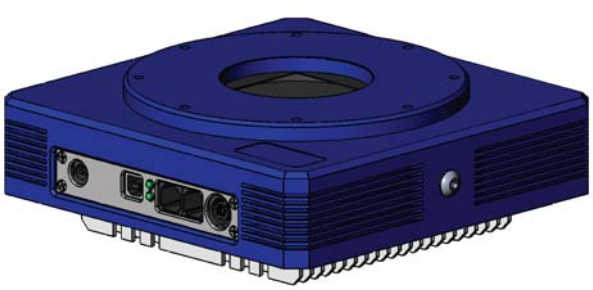


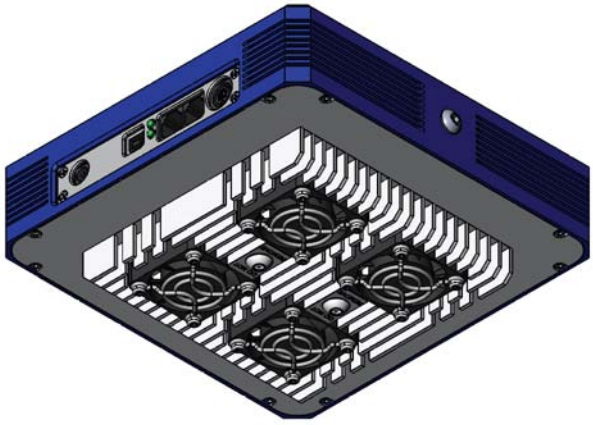
ALTA® Housings: D07 / D11 Low Profile

D07F

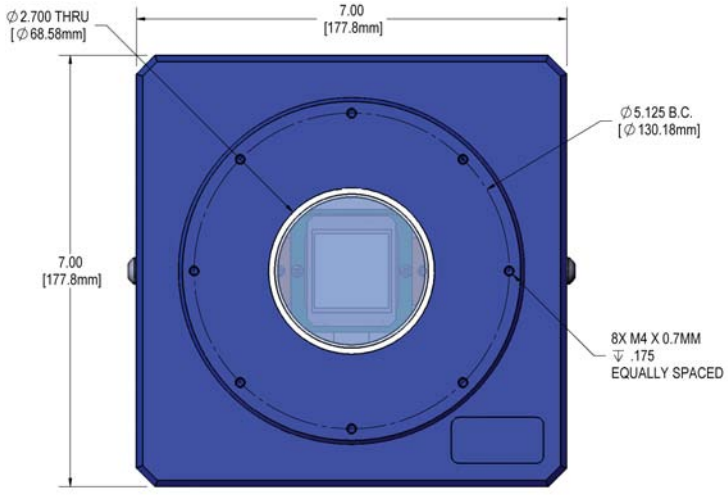


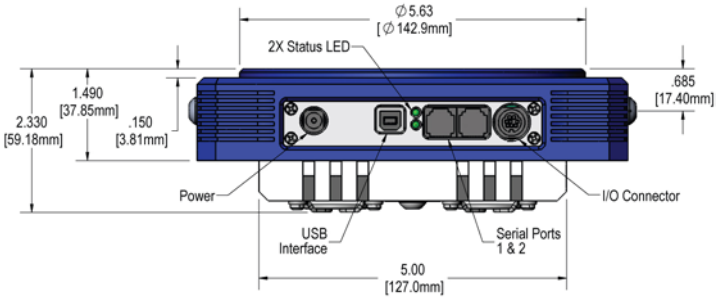


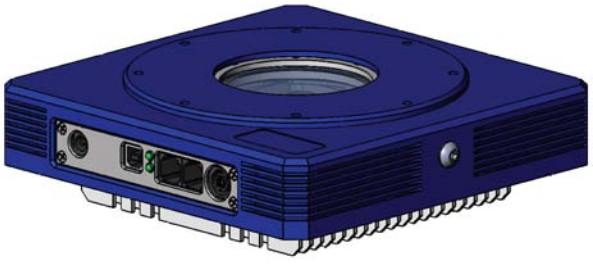




D11F (Low Profile)



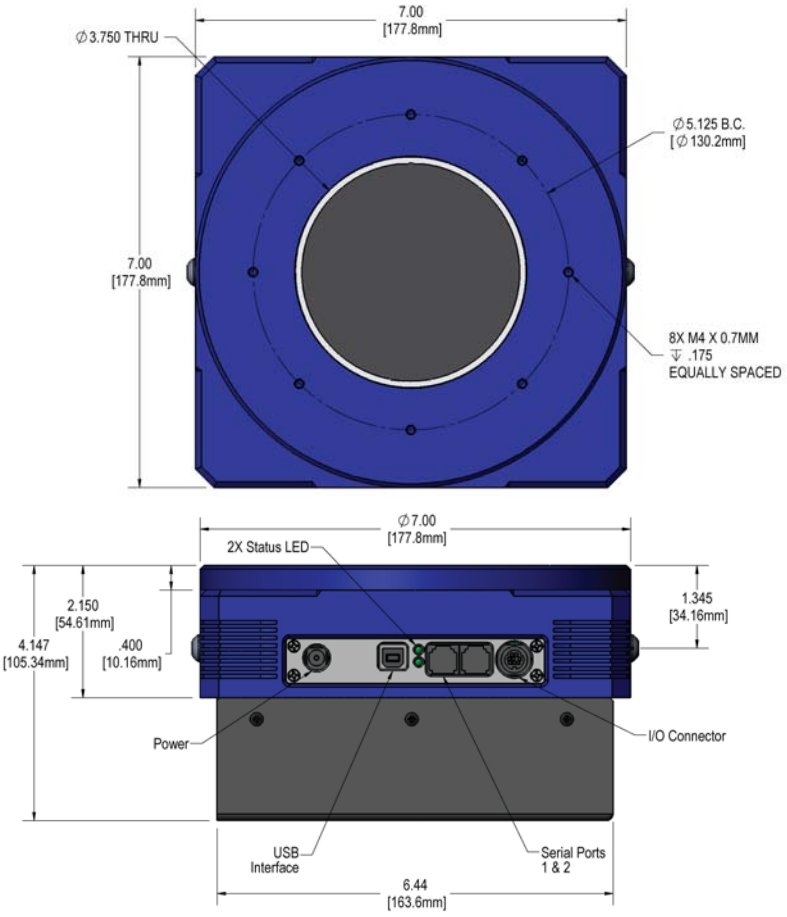


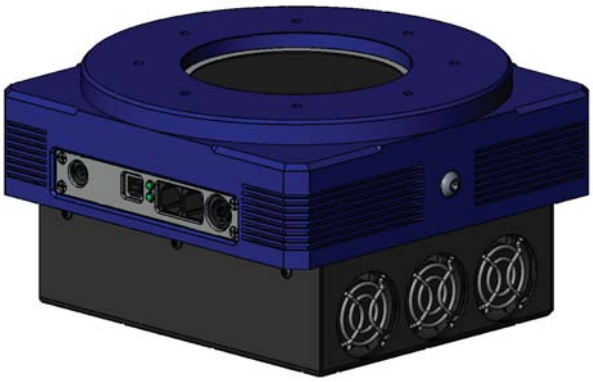


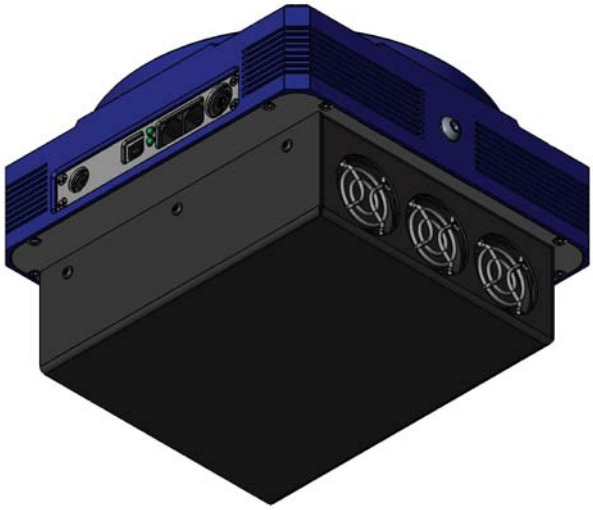
For additional dimensional details, see complete mechanical drawings at www.ccd.com/alta_mechanical.html

D10F

No liquid circulation version of D10 is available.



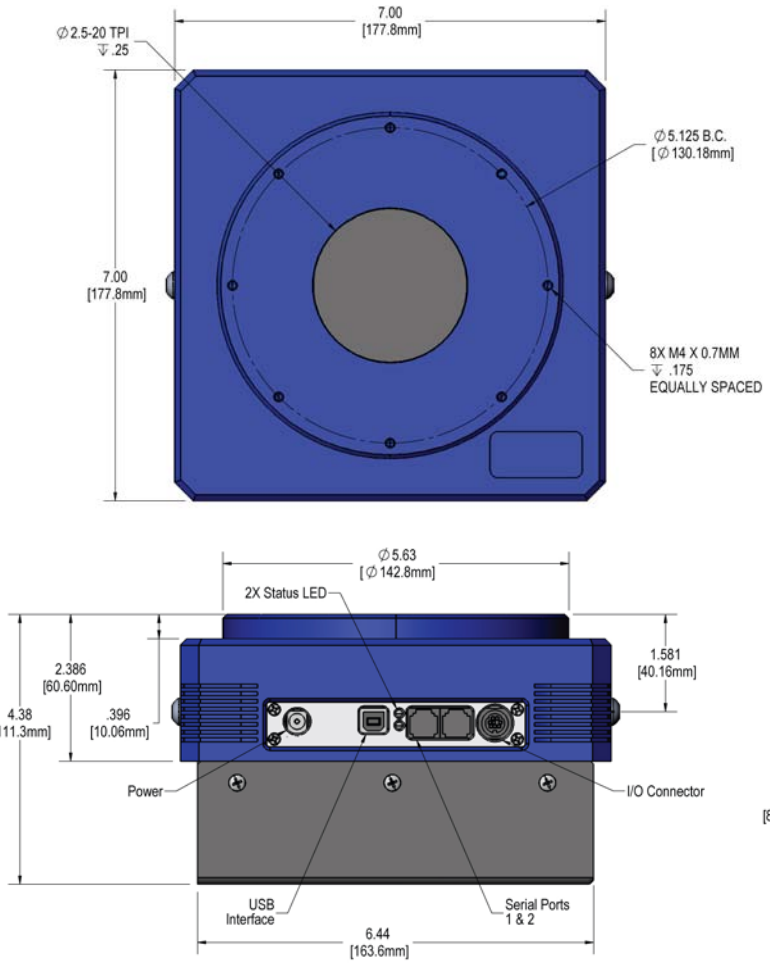




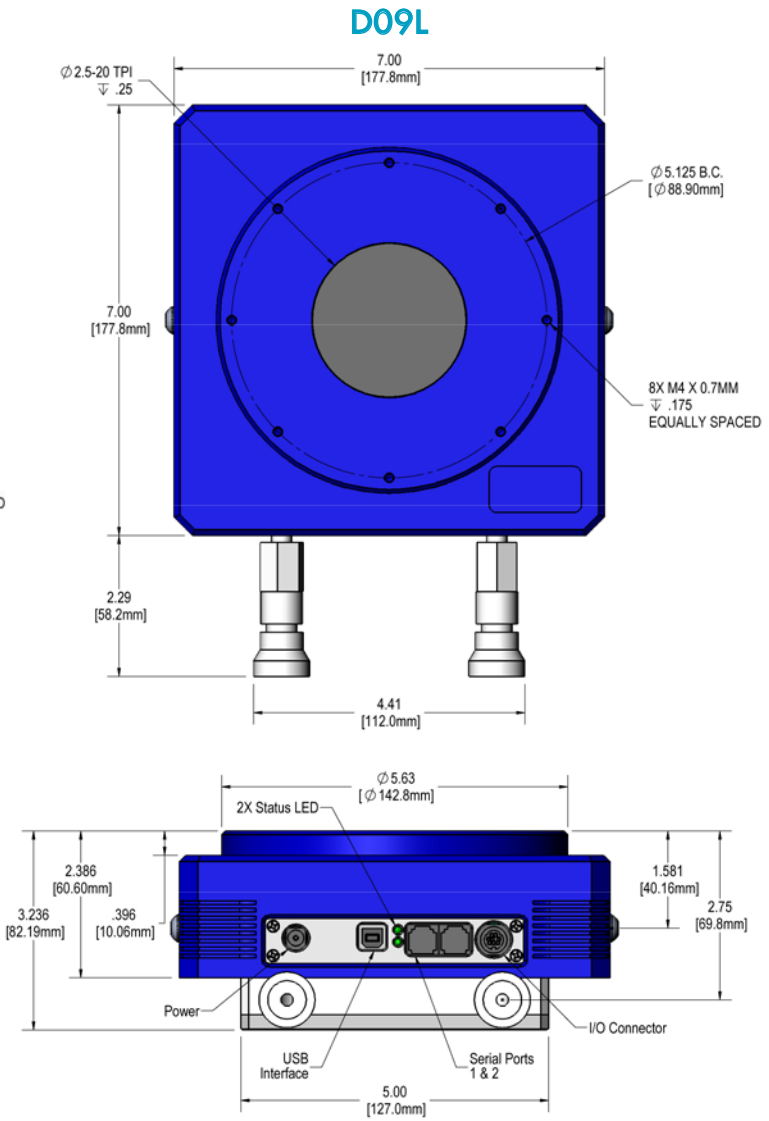
NGC 6188, courtesy Don Goldman. U16M camera.

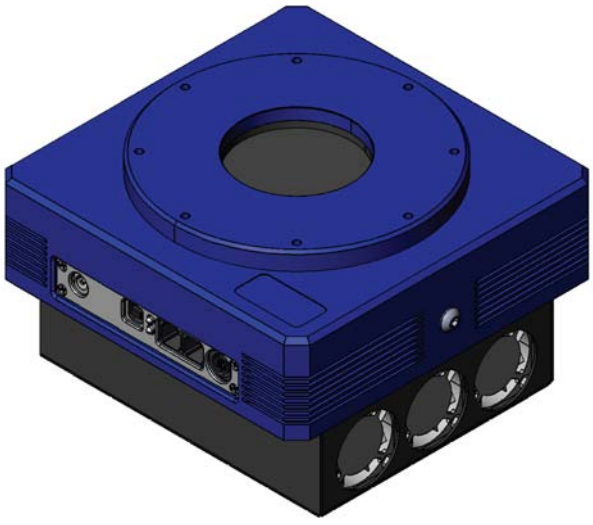
ALTA® Housings: High Cooling D09

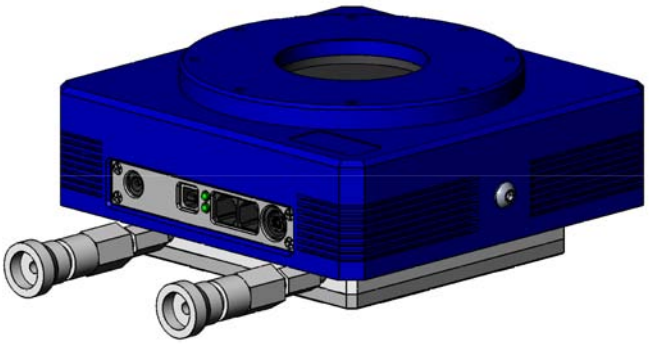
D09F

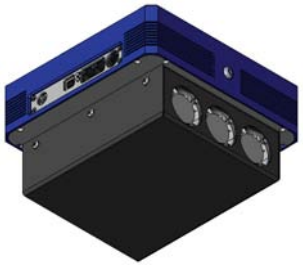


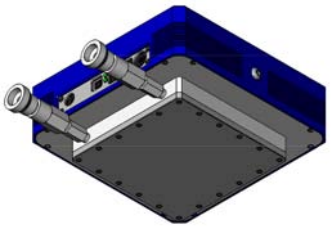
D09L







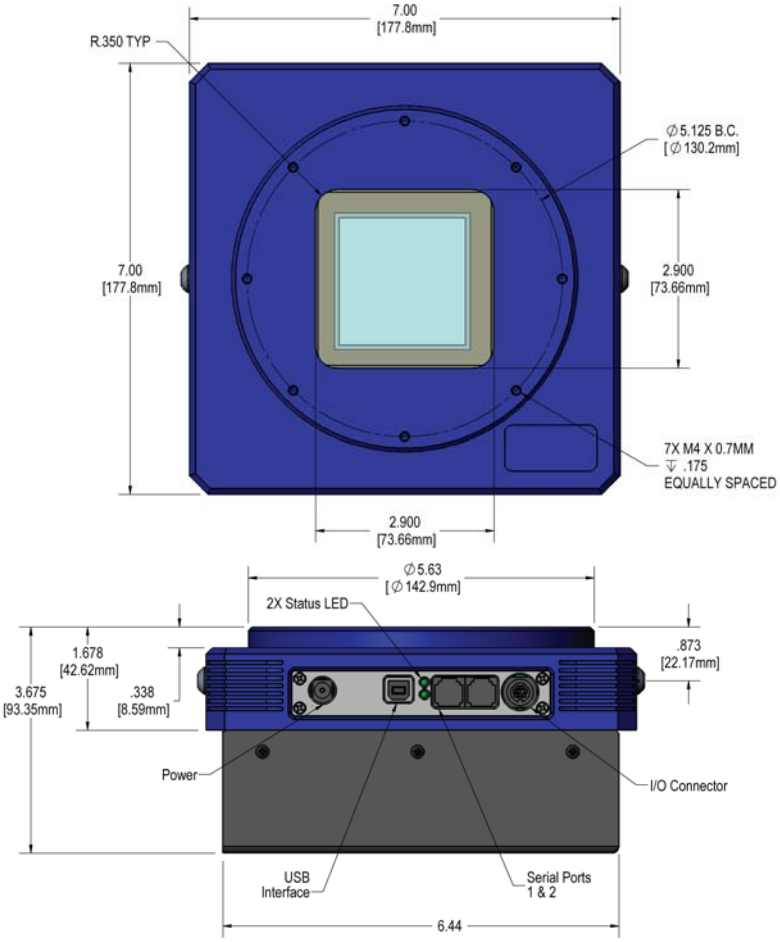




For additional dimensional details, see complete mechanical drawings at www.ccd.com/alta_mechanical.html

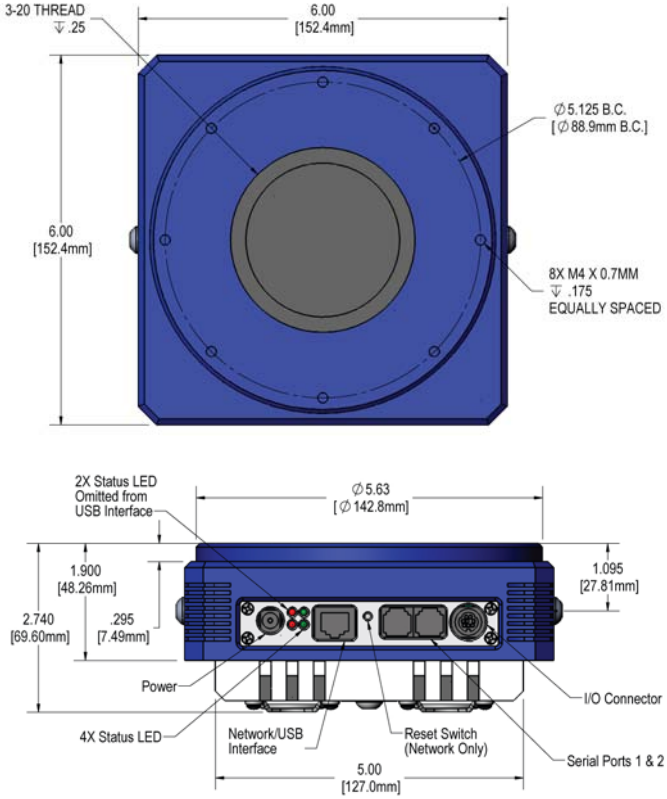
ALTA® Housings: Wide Angle D12 / D13

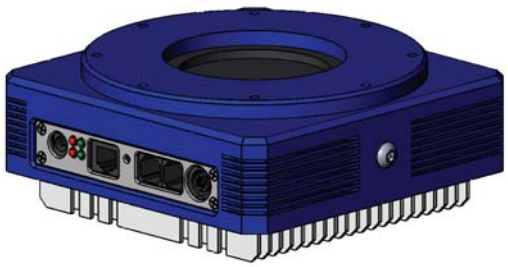
D12F
Wide Angle variant of D10

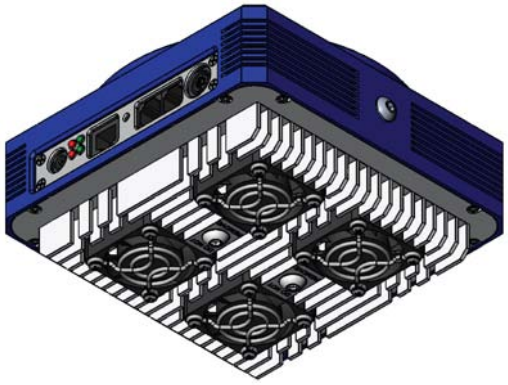


No liquid circulation version of D12 is available.

D13F / (D13L)*
Wide Angle variant of D02







*A liquid circulation version of D13 is also available.

For additional dimensional details, see complete mechanical drawings at www.ccd.com/alta_mechanical.html

ALTA® Full-Frame Front-Illuminated CCDs: Part Numbers

D10F-VS90D-U04320-MNSA

Housing
D01
D02
D05
D06
D07
D09
D10
D11
D12
D13

Heat Transfer
F = Fan
L = Liquid

Shutter
VS25 = Vincent 25mm
MG45 = Melles Griot 45mm
MG63 = Melles Griot 63mm
VS90 = Vincent 90mm
NOSH = No shutter

Inner Chamber Window
S = Single
D = Double
W = Wedge

Interface
U = USB 2.0

16-bit digitization
A = 1 MHz
X = 1.8 MHz

CCD Grade
(as defined by manufacturer)
S = Standard
0 = Grade 0 (e2v only)
1 = Grade 1
2 = Grade 2
H = Grade H (TH7899 only)
E = Grade E (TH7899 only)
X = Engineering Grade

CCD Type
MN = Monochrome, non-microlensed
MM = Monochrome, microlensed
CM = Color, microlensed
OE = Open electrode (e2v)

CCD
00402 = Kodak KAF-0402ME (U1)
A0261 = Kodak KAF-0261E, High Gain (U260)
B0261 = Kodak KAF-0261E, High Dynamic Range
01603 = Kodak KAF-1603 (U2)
03011 = e2v CCD30-11 open electrode (U30-OE)
03200 = Kodak KAF-3200ME (U32)
A1001 = Kodak KAF-1001E, High Gain (U6)
B1001 = Kodak KAF-1001E, High Dynamic Range
06303 = Kodak KAF-6303E (U9)
07899 = e2v TH7899 (U10)
08300 = Kodak KAF-8300 (U8300)
04320 = Kodak KAF-4320 (U43)
09000 = Kodak KAF-09000 (U9000, U9000X)
16803 = Kodak KAF-16803 (U16M)
16801 = Kodak KAF-16801E (U16)
39000 = Kodak KAF-39000 (U39000)
03041 = Fairchild CCD3041 (U3041F)

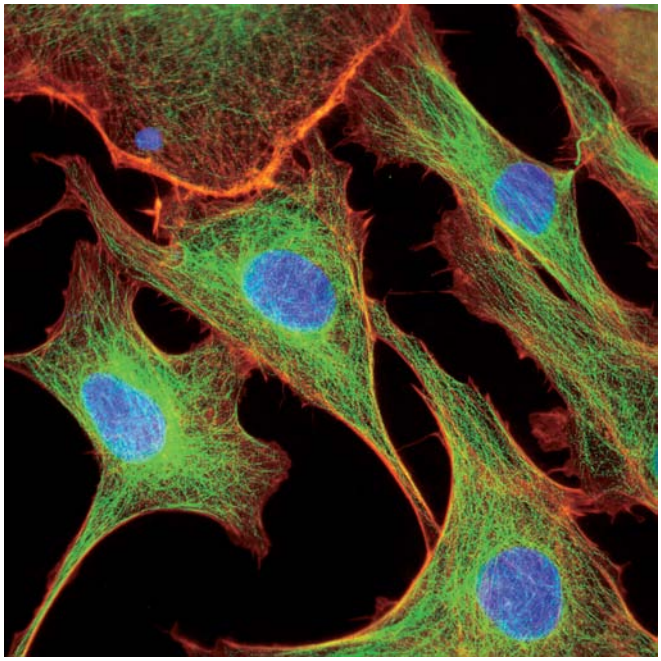


Image courtesy
Scientific Instrument Company.

ALTA® Full-Frame Front-Illuminated CCDs: Available Configurations

Camera	Std Housing*	High Cooling	Low Profile	Wide Angle	Interface	Grades	Digit.
U39000	D10F-VS90S	NA	D12F-NOSHS	NA	U	1	A
U16M	D07F-MG63D	D09*-MG63D	D11F-NOSHD	NA	U	S	A
U16	D07F-MG63D	D09*-MG63D	D11F-NOSHD	NA	U	1, 2	A
U9000	D07F-MG63D	D09*-MG63D	D11F-NOSHD	NA	U	S	A, X
U8300	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	A
U9	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	1, 2	A
U43	D10*-VS90S	NA	NA	D12*-NOSHS	U	1, 2	A
U3041F	D02*-MG43D	NA	D06*-NOSHD	D13*-MG63D	U, E	1	A
U10	D02*-MG43D	NA	D06*-NOSHD	D13*-MG63D	U, E	H, E	A
U32	D01*-VS25D	NA	D05*-NOSHD	NA	U, E	1, 2	A
U2	D01*-VS25D	NA	D05*-NOSHD	NA	U, E	2	A
U6	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	1, 2	A
U1	D01*-VS25D	NA	D05*-NOSHD	NA	U, E	1, 2	A
U260	D01*-VS25D	NA	D05*-NOSHD	NA	U, E	1	A
U30-OE	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	0, 1	A

Items with * are available with fans or with liquid circulation. Liquid circulation is not intended to add cooling, but rather to dissipate heat away from the camera. The fan cooled version is D09F, for example, and the liquid cooled version is D09L.

	D01	D02	D05	D06	D07	D09	D10	D11	D12	D13
Weight (lb.)	3.1	3.1	3.0	2.8	4.2	7.2	7.5	6.3	7.2	3.6
Weight (kg.)	1.4	1.4	1.4	1.3	1.9	3.3	3.4	2.9	3.3	1.6
BFD (inches)*	0.69	1.02	0.46	0.46	1.0	1.4	1.22	0.58	0.70	1.05
BFD (mm)*	17.5	25.9	11.7	11.7	25.4	35.6	31.0	14.7	17.8	26.7

*BFD = Back focal distance, optical (compensating for the optical elements within the camera). Distances are approximate; see mechanical drawings at www.ccd.com/alta_mechanical.html for precise information.

ALTA FILTER WHEEL

Apogee offers an optional filter wheel for nine 2" round filters or seven 2" square filters. The filter wheel can be controlled directly from one of the Alta's COM ports. The filter wheel is pictured here on the optional D09 housing.

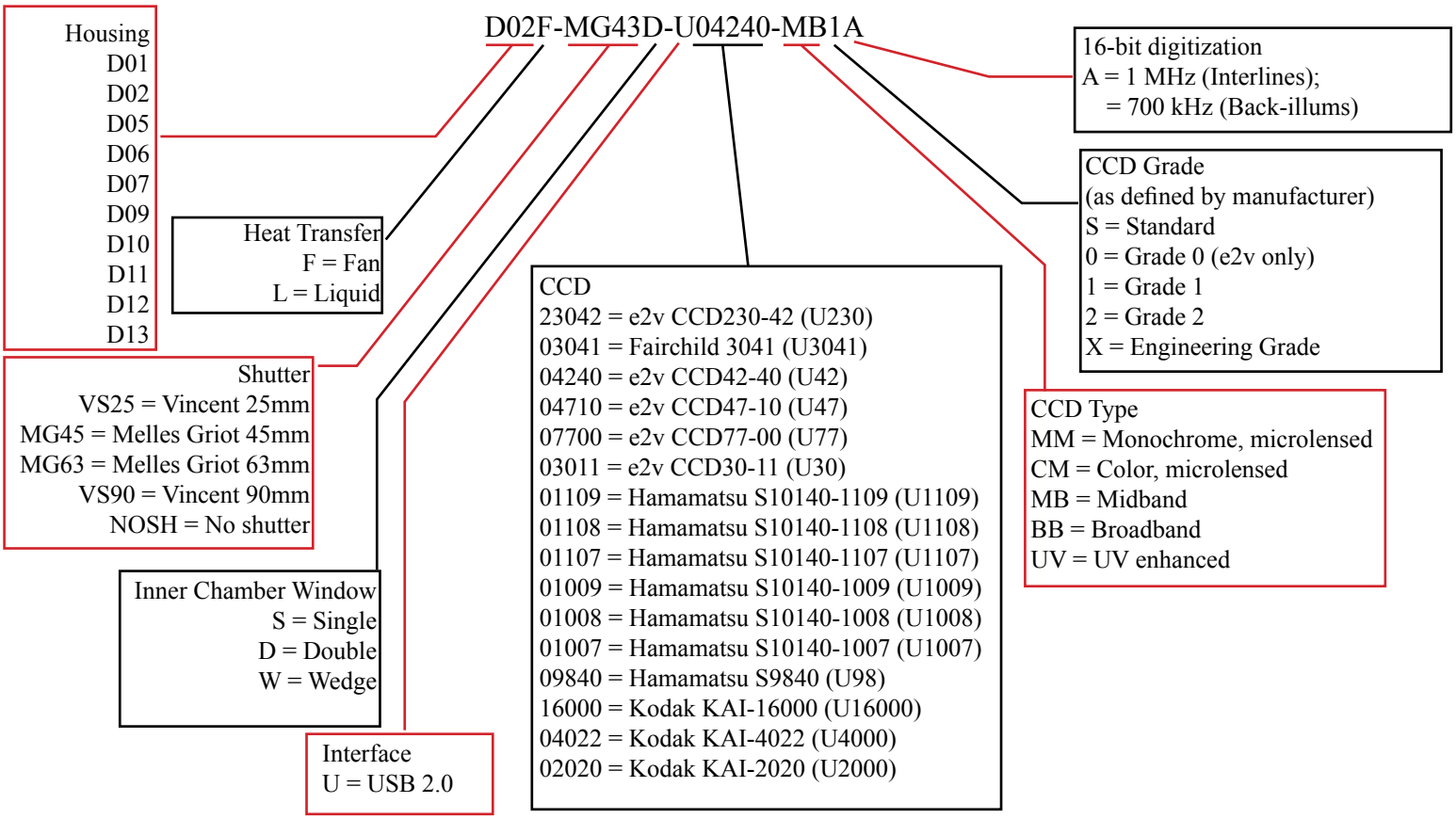
USB2 EXTENDERS

The new Icron USB 2.0 Ranger® extenders support USB cameras at distances from 50 meters (Cat 5 cable) to 10 km (fiber cable).

FACE PLATE ADAPTERS

Flange adapters allow you to attach anything from an SLR camera lens to a large instrument pack to your Apogee camera. We have sizes to fit all Alta and Ascent cameras. These units are machined precisely for accurate concentricity.

ALTA® Back-Illuminated & Interline Transfer CCDs: Part Numbers & Available Configurations



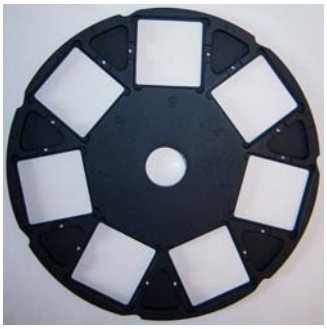
Camera	Std Housing*	High Cooling	Low Profile	Wide Angle	Interface	Grades	Types
Back-illuminated CCDs							
U230	D07F-MG63D	D09*-MG63D	D11F-NOSHD	NA	U	0, 1, 2	MB
U3041	D07F-MG63D	D09*-MG63D	D11F-NOSHD	NA	U	1, 2, 3	BB,UV
U42	D02F-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	0, 1	MB,UV
U47	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	0, 1	MB,BB,UV
U77	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	0, 1	MB
U30	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	0, 1	MB, UV
U1109	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
U1108	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
U1107	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
U1009	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
U1008	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
U1007	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
U98	D02*-MG43D	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	UV
Interline Transfer CCDs							
U16000	D07F-MG63D	D09*-MG63D	D11F-NOSHD	NA	U	1, 2	MM,CM
U4000	D02*-NOSHD	D09*-MG63D	D06*-NOSHD	D13*-MG63D	U, E	S	MM,CM
U2000	D01*-NOSHD	NA	D05*-NOSHD	NA	U, E	S	MM,CM

1. Items with * are available with fans or with liquid circulation. Liquid circulation is not intended to add cooling, but rather to dissipate away from the camera. The fan cooled version is D09F, for example, and the liquid cooled version is D09L.
2. The U4000 and U2000 are optionally available with internal shutters, D01*-VS25D and D02*-MG43D, respectively.
3. The U47 is also available in a C-mount configuration, D01*-VS25D. However, the CCD is a 1.2” format by video standards (19mm diagonal) so is too large for most C-mount lenses.

AFW Filter Wheels

The AI-FW50 series of filter wheels provide filtering solutions for Alta and Ascent cameras with large format CCDs, such as the A16000. The AFW50-9R filter wheel provides 9 positions for 50mm / 2" round filters. The AFW50-7S and AFW50-10S provide 7 and 10 positions for 50mm / 2" square filters, respectively. The filter wheels are controlled via USB 2.0. The filter wheels easily adapt to Alta and Ascent bodies.

AFW-50-9R Carousel
9 positions for 50mm
round filters



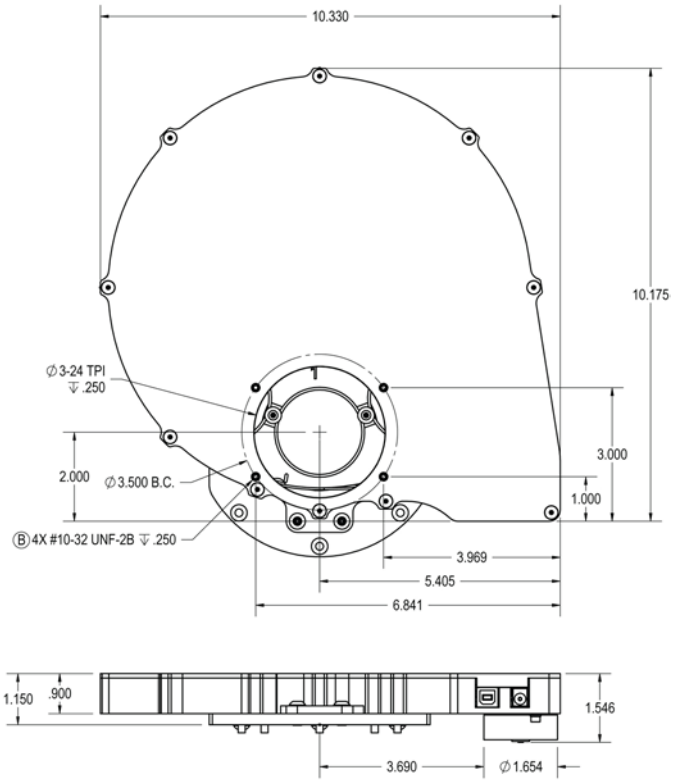
AFW-50-7S Carousel
7 positions for 50mm
square filters

AFW-50-10S Carousel
10 positions for 50mm
square filters

AFW50-7S Filter wheel with Alta
adapter plate

Max. filter thickness	7 mm
Weight	3.5 lbs. (1.6 kg) with filters
Thickness	1.15" (2.92 cm) with mounting plate
Camera mount method	Adapter plate attached to Alta, Ascent or AP camera
Mechanical mount	3" 24 threads/inch
Power input	12V DC (int'l power supply included)
Interface	USB 2.0

Filter wheel mounted on Alta D09 camera body



(All dimensions in inches)

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