ANDOR™
TECHNOLOGY

User's Guide

New iStar ICCD

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SAFETY & AND WARNINGS INFORMATION

PLEASE READ THIS INFORMATION FIRST

1. To ensure correct and safe operation of this product, please read this guide before use and keep it in a safe place for future reference
2. If the equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired
3. Before using the system, please follow and adhere to all warnings, safety, manual handling and operating instructions located either on the product or in this User Guide
4. The New iStar camera is a precision scientific instrument containing fragile components: always handle with care
5. Do not expose the product to extreme hot or cold temperatures outside of the storage and operation specifications
6. Ensure that a minimum clearance of approximately 100 mm (4”) is maintained in front of all ventilation slots and the fan inlet and outlet. Cooling performance cannot be guaranteed unless these criteria are observed
7. To prevent accidental internal damage to the camera, objects small enough to enter the slots on the sides and top of the camera should be placed well away from these interfaces
8. Do not expose the product to open flames
9. Do not allow objects to fall on the product
10. Do not expose the product to moisture, wet or spill liquids on the product. Do not store or place liquids on the product. If spillage occurs on the product, switch off power immediately, and wipe off with dry, lint-free cloth. If any ingress hasoccurred or is suspected, unplug mains cable, do not use, and contact Andor Customer Service
11. The product contains components that are extremely sensitive to static electricity and radiated electromagnetic fields,and therefore should not be used, or stored, close to EMI/RFI generators, electrostatic field generators, electro magneticor radioactive devices, or other similar sources of high energy fields
12. Operation of the system close to intense pulsed sources (e.g. plasma sources, arc welders, radio frequency generators,X-ray instruments, and pulsed discharge optical sources) may compromise performance if shielding to the New iStar is inadequate
13. Use only the power supply cord provided with the system for this unit. Should this not be correct for your geographical area please contact your local Andor representative
14. Only the correctly specified mains supply and fuse must be used
15. Make sure the electrical cord is located so that it will not be subject to damage
16. Always disconnect the power supply from the product before replacing a fuse
17. The camera should be mounted so that mains supply can be easily disconnected in case of emergency
18. There are no user-serviceable parts beyond the specified user accessible areas of the product and the enclosure must not be opened. Only authorised service personnel may service this equipment. If the head is opened, warranty will be void
19. Always ensure that the temperature of liquid coolant circulated through the camera head is above the dew point as defined by the environment the camera will be subjected to. Use of coolant at / below the dew point will result in permanent damage to the camera head, due to formation of condensation on internal components
20. Leakage / spillage of coolant onto system components could result in permanent damage. The user should routinely check all coolant hoses and connections for signs of leakage, damage or wear. All seals must be intact before powering on camera system and any worn / damaged items must be replaced immediately
21. Users must be authorised and trained personnel only; otherwise this may result in personal injury, and/or equipment damage and impaired system performance

ADDITIONAL NOTE - AVOIDING DAMAGE TO THE NEW ISTAR DETECTOR

An ICCD is a very sensitive instrument, though with care and good working practice, it should last many years.

1. There are two major potential forms of damage to be considered:

   - **Bleaching of the photocathode** brought about by over-illuminance of this photo-sensitive interface

     Bleaching of the photocathode reduces the Quantum Efficiency (QE) response (it can render it completely unresponsive) and permanently increases the background noise of the Image Intensifier.
   - **Ion damage of the cathode** brought about by excessive numbers of photoelectrons in the Multichannel Plate (hereinafter referred to as the MCP). As a general rule of thumb, when the CCD is already saturated, this type of damage is liable to occur.

     Excessive numbers of photoelectrons in the MCP brought about by excessive input light levels, or moderate light levels and excessive gain can damage both the photocathode, MCP or the phosphor screen.

     If the multichannel plate is overloaded with incoming electrons, it is much more likely for positive ions to be knocked out of the walls of the multichannel plate by the colliding electrons. These ions are accelerated towards the photocathode and can do considerable mechanical damage.

     Excessive electrons can also increase the outgassing rate inside the tube to the point where the vacuum is seriously diminished.

     The protection circuitry in the New iStar monitors the current drawn by the phosphor, which is indirectly linked to the incident signal intensity as seen through the MCP gain chain. Above a certain level the high voltage power supply at the MCP shuts down to prevent damage. However, when only a sub-section of the phosphor / photocathode is illuminated, damage can occur without the high voltage supply shutting down. Applications involving focusing of strong spectral line features, or confined bright spots in a imaging scenario must therefore be treated with appropriate caution.

The following best practices should be observed:

- Always maintain the measured signal below the saturation level of the CCD. This should constitute a safe operating condition in most circumstances.
- Do not focus features of <50 µm on the photocathode (i.e. stay around the resolution limit of the New iStar). For example, a 10 µm feature might be sufficiently intense to damage the photocathode but, when it is smeared out to ~ 50 µm, it may not be saturating the CCD and therefore satisfies the general guideline above. This applies to images and to spectra. Be particularly careful with automatic spectrographs that reset themselves with the brighter zero order on the center of the focal plane.
- Always keep the photocathode covered when the detector is not in use (the photocathode will degrade even when switched off). This can be facilitated by using a mechanical shutter whenever possible.
- If user is unsure of the signal levels to be detected, one should start with low signal levels and build up. At minimum gain, the sensitivity of the New iStar is similar to a front illuminated CCD, so if necessary, use a CCD detector to check the signal level.
- User should protect the New iStar from mechanical shock both in use and in transit as damage to the intensifier tube may result from sharp jolts.

2. To remove dirt or fingerprints on the input window of the image intensifier, please contact your local Andor representative for advice on how to best clean this interface.
3. Turning off the New iStar camera through mains or camera On/Off switch during acquistion or cooling may result in damage to the camera. When possible, ensure sensor cooling temperature should be > 0°C (after switching Off the cooler) before turning off the camera.
4. Prior to mounting the camera on an optical system, the black grommet which covers the image intensifier and protects it from unwanted photo-bleaching must be carefully removed without the use of any tools such as screwdrivers.

SAFETY SYMBOLS

The following are explanations of the safety symbols found on this product:

Caution, potential hazard

Caution, risk of electric shock

This product has been tested to the requirements of CAN/CSA-C22.2

No. 61010-1, 2nd edition, including Amendment 1, or a later version of the same standard incorporating the same level of testing requirements.

REGULATORY COMPLIANCE

Please refer to the Declaration of Conformity in Section A1 of this User Guide.

SECTION 1 - ABOUT THE NEW iSTAR

1.1 - INTRODUCTION

Thank you for choosing the Andor New iStar ICCD. From the outset, the New iStar has been designed for ease of use, providing the latest in CCD electronics and integrated, ultra-fast, gated image intensifiers. The on-board Digital Delay Generator (DDG™) provides seamless and precise control of all timings within the camera through Andor Solis software or Andor Software Development Kit (SDK).

This camera is designed to be used in research laboratories and other controlled scientific environments.

If you have any questions regarding your New iStar system, please feel free to contact your local Andor representative. Contact details are available in Section 1.3.

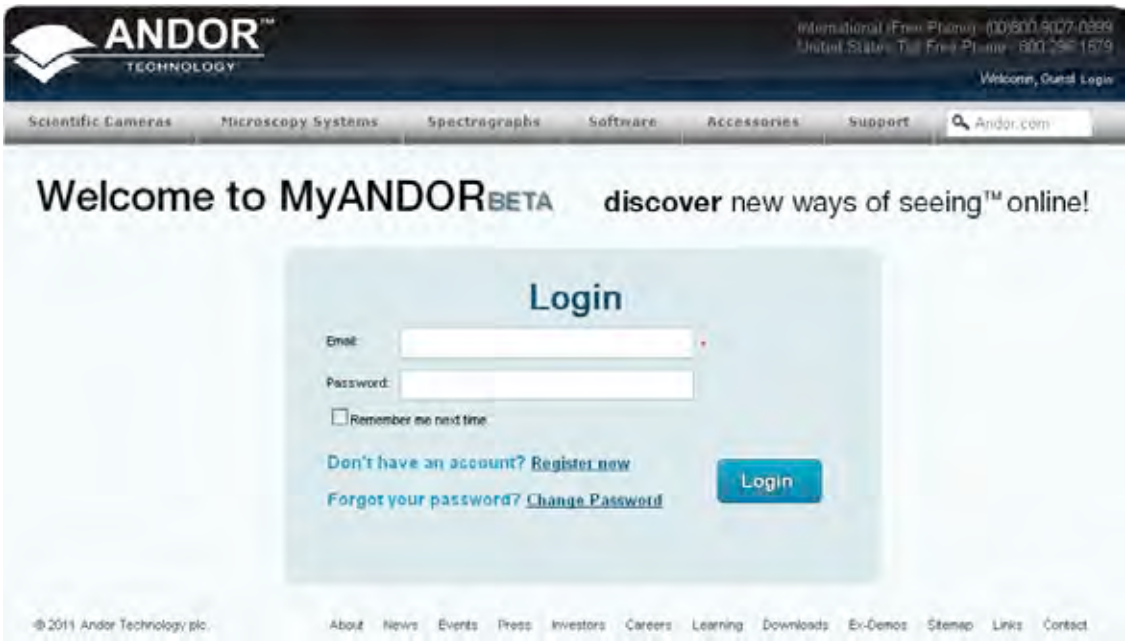
1.2 - WORKING WITH THE USER GUIDE

This User Guide is your 'road-map' to the Andor New iStar software and hardware. In the software section, all the controls needed for an operation are grouped and sequenced appropriately in on-screen windows.

As far as possible, the descriptions in this User Guide are laid out in sections that mirror the Windows Interface and use standard Windows terminology to describe the features of the user interface.

If user is unfamiliar with Windows, the documentation supplied with the Windows installation pack will provide users with a more comprehensive overview of the Windows environment.

Should this User Guide be misplaced or an electronic copy be required, please visit MyAndor at: andor.com/my and follow the download instructions (log-in is required).



1.3 - HELP & TECHNICAL SUPPORT

For have any questions regarding the use of this equipment, please contact the representative from whom the system was purchased, or alternatively use the following details:

Europe

Andor Technology plc

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The latest contact details for local representatives can be found on our website via the following link:

andor.com/support

1.4 - DISCLAIMER

The information contained herein is provided “as is” without warranty, condition or representation of any kind, either express, implied, statutory or otherwise, including but not limited to, any warranty of merchantability, non-infringement or fitness for a particular purpose.

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The publication of information in this documentation does not imply freedom from any patent or proprietary right of Andor Technology plc or any third party.

1.5 - TRADEMARKS & PATENT INFORMATION

Andor, the Andor logo, New iStar & Solis are trademarks of Andor Technology plc. All other marks are property of their owners. Changes are periodically made to the product and these will be incorporated into new editions of the manual.

1.6 - ELECTRICAL & ENVIRONMENTAL SPECIFICATIONS

PARAMETER	SPECIFICATION
Power supply ratings	100 - 240 V, 50 - 60 Hz, 1.6 A
Power consumption	85 W continuous
Location to be used	Indoor use only
Altitude	Up to 2,000 m
Operating temperature range	0°C to 40°C
Storage temperature	-20°C to +55°C
Operating relative humidity	< 70% non-condensing
Overvoltage category	CAT II
Pollution degree	2
Ingress protection rating	IP20
Electromagnetic compatibility	This is a Class A product. In a domestic environment this product may cause electromagnetic interference, in which case the user may be required to take adequate measures
Cooling vent clearance	100 mm minimum
Dimensions (W x D x H)	110.7 x 231.0 x 137.2 mm [4.36 x 9.09 x 5.40 inches]
Weight	4.2 kg [9 lb 4 oz], power supply = 0.65 kg [1 lb 4 oz]

Note: Specifications are subject to change without notice

SECTION 2 - INTRODUCTION TO THE NEW iSTAR

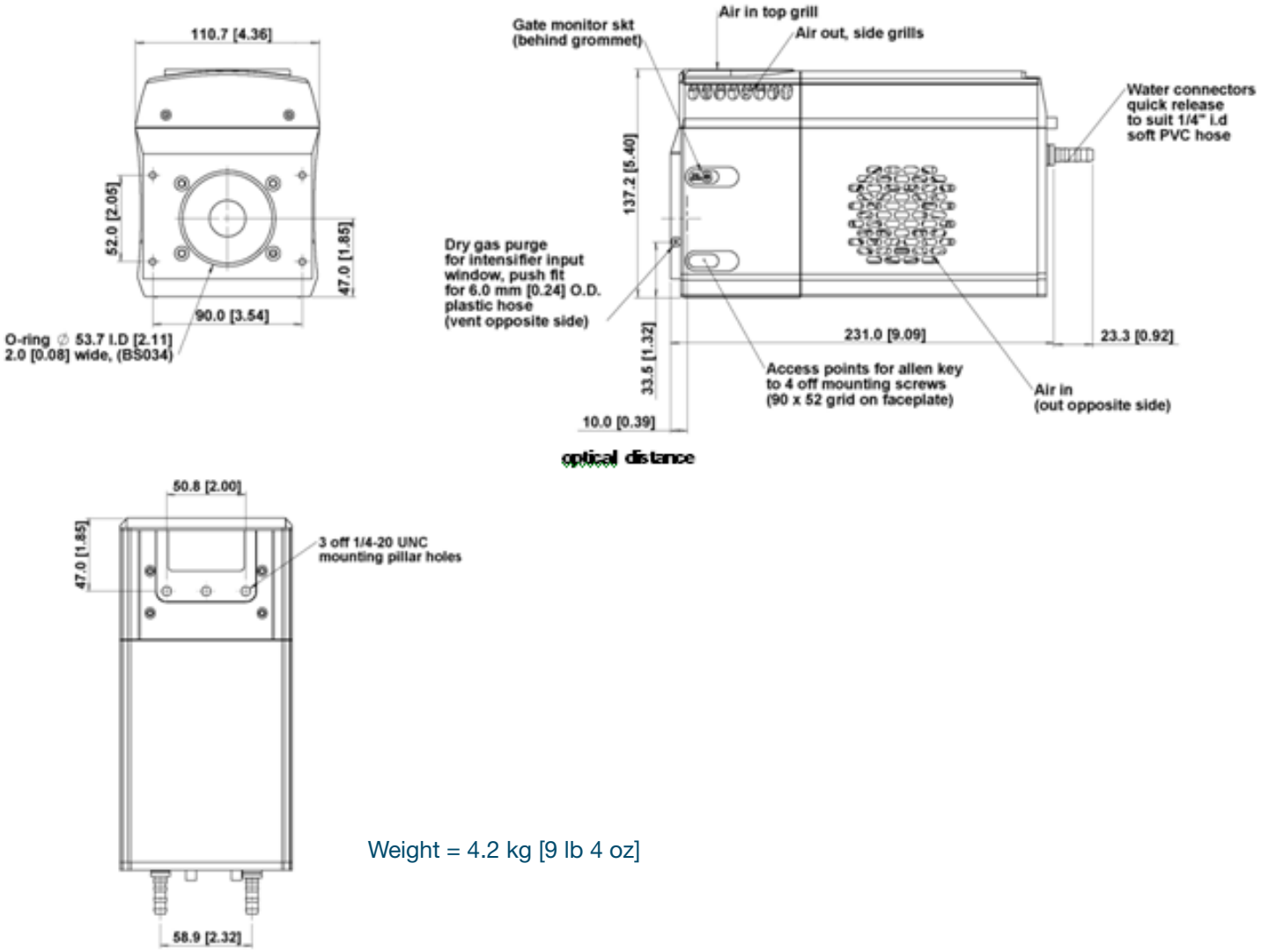
2.1 - COMPONENTS OVERVIEW

THE MAIN COMPONENTS OF THE ANDOR NEW ISTAR SYSTEM ARE AS FOLLOWS:

- iStar camera head (see **Figure 1** below), which contains the following items:
  - CCD sensor with integrated drive and readout electronics
  - Image Intensifier tube with associated drive and gating circuitry
  - Digital Delay Generator (DDG™)
  - Thermoelectric cooling interface
  - Input & output connectors (including USB, triggering and gating signal monitoring)
- 1x USB 2.0 cable for connection to PC
- 2x BNC to SMA cables (for synchronization with external events / equipment)
- 1x Gate monitor cable
- Power Supply Unit (PSU) PS-90:
  - PowerPax SW4189 (Model STD-12090 with 3-pin Redel Connector Fitted)
- Software in CD format (if ordered)
- User Guide in CD format
- Performance sheet detailing the technical performance for your individual camera system

Figure 1: New iStar camera

2.2 - MECHANICAL DRAWINGS



Weight = 4.2 kg [9 lb 4 oz]

Figure 2: New iStar mechanical layout

Note: The 10 mm optical distance is taken from the front surface of the input faceplate.

2.3 - CCD PLATFORM SPECIFICATIONS - IMAGING SENSORS

MODEL	312T	334T	
Total CCD matrix size (pixels)	512 x 512	1024 x 1024	
Fibre optic taper magnification (std)	Ø 18 mm II 1:1	Ø 18 mm II 1:1	Ø 25 mm II 1.5:1
Effective CCD pixel size	24 x 24 µm 100% fill factor	13 x 13 µm 100% fill factor	19.5 x 19.5 µm 100% fill factor
Effective active area	12.3 x 12.3 mm	13.3 x 13.3 mm	
Image pixel well depth	320,000 e^-	100,000 e^-	
Register well depth	480,000 e^-	150,000 e^-	
Read noise (e^-) 50 kHz 1 MHz 3 MHz 5 MHz	 5.4 [7] 10 [14] 16 [20] 24 [50]	 5 [7] 8 [12] 14 [18] 20 [50]	
Maximum frame and spectral rates Frame [2 x 2 binning] Crop mode (frame, 10 rows) FVB Crop mode (spectrum, 10 rows) Fast Kinetics 4 rows 2 rows	 15.8 fps [28.5 fps] 633 fps 291 sps 5,556 sps 32,150 Hz 55,250 Hz	 4.2 fps [7.3 fps] 333 fps 145 sps 3,450 sps 29,850 Hz -	
Sensitivity	2 to 10 e^-/count (software selectable)	1 to 5 e^-/count (software selectable)	
Linearity	Better than 99%		
Minimum temperature air cooled [dark current, e^-/pixel/sec]	Ø 18 mm II -30°C [0.4]	Ø 18 mm II -30°C [0.2]	Ø 25 mm II -25°C [0.4]
Coolant chiller, coolant @ 10°C, 0.75 l/min [dark current, e^-/pixel/sec]	-40°C [0.12]	-40°C [0.1]	-35°C [0.15]

Note: All specifications are typical unless otherwise stated

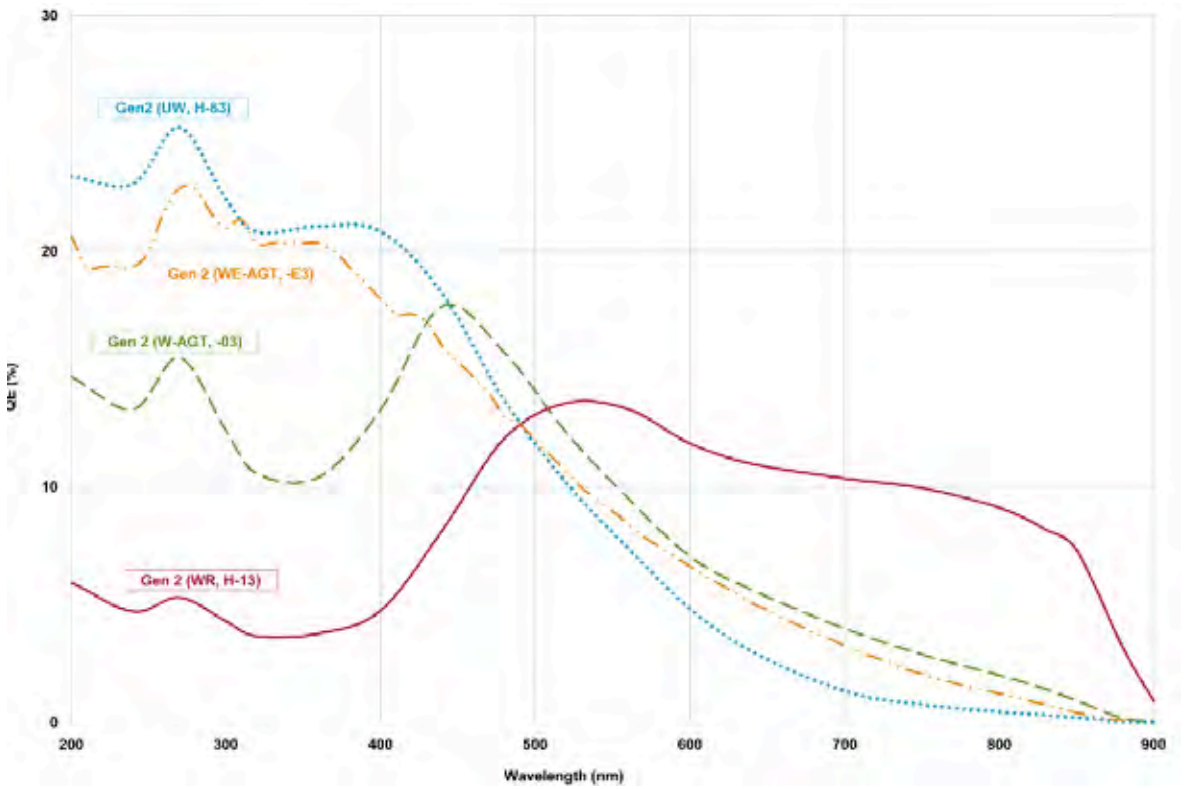
2.4 - CCD PLATFORM SPECIFICATIONS - SPECTROSCOPY SENSORS

MODEL	320T		340T	
Total CCD matrix size (pixels)	1024 x 255		2048 x 512	
Fibre optic taper magnification (std)	Ø 18 mm II 1:1	Ø 25 mm II 1:1	Ø 18 mm II 1:1	Ø 25 mm II 1:1
Effective CCD pixel size	26 x 26 µm 100% fill factor		13.5 x 13.5 µm 100% fill factor	
Effective active area	18 x 6.7 mm	25 x 6.7 mm	18 x 6.9 mm	25 x 6.9 mm
Image pixel well depth	500,000 e^-		100,000 e^-	
Register well depth	550,000 e^-		150,000 e^-	
Read noise (e^-) 50 kHz 1 MHz 3 MHz 5 MHz	 7 [9] 12 [13] 19 [20] 25 [32]		 6 [8] 9 [12] 12 [18] focussing mode only	
Maximum frame and spectral rates				
Frame [2 x 2 binning] Crop mode (frame, 10 rows)	15.9 fps [28.9 fps] 320 fps		2.5 fps [5.6 fps] 184 fps	
FVB Crop mode (spectrum, 10 rows)	322 sps 2,941 sps		135 sps 1,825 sps	
Fast Kinetics 4 rows 2 rows	 16,610 Hz 26,590 Hz		 16, 950 Hz -	
Sensitivity	2 to 10 e^-/count (software selectable)		1 to 5 e^-/count (software selectable)	
Linearity	Better than 99%			
Minimum temperature air cooled [dark current, e^-/pixel/sec]	Ø 18 mm II -30°C [0.4]		Ø 18 mm II -30°C [0.2]	Ø 25 mm II -25°C [0.4]
Coolant chiller, coolant @ 10°C, 0.75 l/min [dark current, e^-/pixel/sec]	-40°C [0.12]		-40°C [0.1]	-35°C [0.15]

Note: All specifications are typical unless otherwise stated

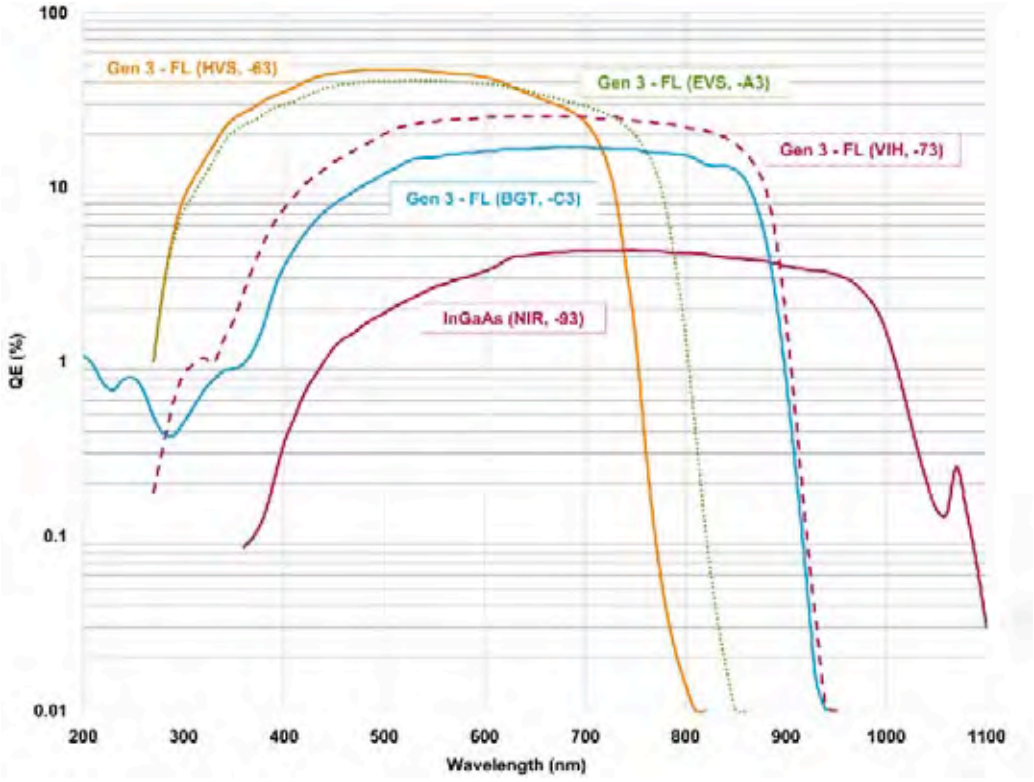
2.5 - GEN 2 INTENSIFIER SPECIFICATIONS

PHOTOCATHODE MODEL	18*-03	18*-04	18*-05.0	18H-13	18H-83	18*-E3	25*-03
Useful aperture	Ø18 mm						Ø 25 mm
Input window	Quartz	Quartz	MgF_2	Quartz	Quartz	Quartz	Quartz
Photocathode type	W-AGT	W-AGT	W-AGT	WR	UW	WE-AGT	W-AGT
Peak QE @ room temperature	18	18	15	13.5	25	22	16
Wavelength range (nm)	180 - 850	180 - 850	120 - 850	180 - 920	180 - 850	180 - 850	180 - 850
Image intensifier resolution limit	25 µm	30 µm	25 µm	25 µm	25 µm	25 µm	35 µm
Phosphor type [decay time to 10%]	P43 [2 ms]	P46 [200 ns]	P43 [2 ms]	P43 [2 ms]	P43 [2 ms]	P43 [2 ms]	P43 [2 ms]
Minimum optical gate width (ns)							
U (Ultrafast)	< 2	< 2	< 5	-	-	< 2	< 3
F (Fast)	< 5	< 5	< 10	-	-	< 5	< 7
H (High QE)	-	-	-	< 50	< 100	-	-
Maximum relative gain	> 1000	> 500	> 1000	> 850	> 500	> 300	> 1000
Maximum photocathode repetition rate (with Intelligate™ OFF)	500 kHz (continuous)						
Maximum photocathode repetition rate (with Intelligate™ ON)	5 kHz (continuous)						
Equivalent Background Illuminance (EBI) (e^-/pix/sec)	< 0.2						



2.6 - GEN 3 INTENSIFIER SPECIFICATIONS

PHOTOCATHODE MODEL	18*-63	18*-73	18*-93	18*-A3	18*-C3
Useful aperture	Ø18 mm				
Input window	Glass	Glass	Glass	Glass	MgF_2 + F/O + Lumogen
Photocathode type	HVS	VIH	NIR	EVS	BGT
Peak QE @ room temperature	47.5	25.5	4	40	17
Wavelength range (nm)	280 - 760	280 - 910	380 – 1090	280 - 810	< 200 - 910
Image intensifier resolution limit	30 µm	30 µm	30 µm	30 µm	40 µm
Phosphor type [decay time to 10%]	P43 [2 ms]				
Minimum optical gate width (ns)					
U (Ultrafast)	< 2				
F (Fast)	< 5				
Maximum relative gain	> 200				
Maximum photocathode repetition rate(with Intelligate™ OFF)	500 kHz (continuous)				
Maximum photocathode repetition rate (with Intelligate™ ON)	5 kHz (continuous)				
Equivalent Background Illuminance (EBI) (e^-/pix/sec)	< 0.1	< 0.3	< 2	< 0.2	< 0.3



2.7 – DDG™ SPECIFICATIONS

THE NEW ISTAR HOLDS A FULLY INTEGRATED SOFTWARE-CONTROLLED DIGITAL DELAY GENERATOR (DDG) WITH THE FOLLOWING SPECIFICATIONS:

Gate pulse delay & width	• Adjustable from 0 ns to 10 s in 10 ps steps • Software controlled, pre-programmed or real-time
TRIGGER OUTPUTS	
Output A, B and C	• 3x output, +5V CMOS level with 50 Ω source impedance; can drive 5V into a non-terminating load or 2.5V into 50 Ω load; output synchronized triggers for auxiliary equipment, e.g. lasers, flash lamps, or National Instrument™ hardware • Individual delays control from 0 ns to 10 s in 10 ps steps • Configurable polarity • Software controlled, pre-programmed or real-time
Fire	• 5V CMOS level reference signal for beginning and end of individual CCD exposure
Arm monitor	• 5V CMOS level reference signal to indicate when system is ready to accept external triggers. Signal goes high when system is ready to accept external triggers (after a complete readout has finished) including keep clean and goes low when the exposure is finished
Gate & output A, B and C jitter	• 35 ps rms (relative to external trigger signal)
TRIGGER INPUTS	
External trigger	• Trigger input for CCD and Digital Delay Generator • Up to 500 kHz for Integrate-On-Chip mode • Software-configurable polarity, termination and trigger threshold • Fast external software option for most rapid camera response to external trigger (CCD keep clean interruption) – no need for pre-trigger pulse
Direct gate	• TTL input for exact external control of photocathode width and timing with smallest insertion delay.
ADDITIONAL CONTROLS	
Gate monitoring	• AC coupling from photocathode to monitor exact photocathode On/Off switching and timings
Insertion delay	• < 19 ns in direct gate operation

2.8 - COOLING

The New iStar detector is cooled using a thermoelectric (TE) cooler which is a small, electrically powered devices with no moving parts, making it very reliable and convenient. A TE cooler acts as a heat pump, i.e. it achieves a temperature difference by transferring heat from its 'cold side' (the CCD-chip within the New iStar camera head) to its 'hot side' (the built-in heat sink).

Therefore the minimum absolute operating temperature of the New iStar sensor depends on the temperature of the heat sink. The advanced thermal design of the New iStar means that a maximum temperature difference of over 60°C can be achieved. The maximum temperature difference that a TE device can attain is dependent on the following factors:

- Heat load created by the CCD sensor, fiber-optic coupling to the intensifier and camera head design
- Number of cooling stages of the TE cooler
- Operating current
- Operating temperature of TE cooler

The minimum temperature, to which the sensor within the New iStar can be cooled, will be dependent on either the room temperature (when air-cooling is employed) or the coolant temperature circulating through the heat sink (when liquid cooling is utilized).

2.8.1 - Air Cooling

Air cooling is the most convenient method of removing heat from the detector head, but it will not achieve as low an operating temperature as water cooling. Even with a fan, a heat sink typically needs to be 10°C hotter than the ambient (room) temperature to transfer heat efficiently to the surrounding environment. Therefore the minimum CCD temperature that can be achieved will be dependent on the room temperature.

The table below is a guide to the minimum achievable cooling for various ambient temperatures. Performance of individual systems will vary slightly.

Air Temperature	CCD Temperature	
	Ø 18 mm	Ø 25 mm
20°C	-30°C	-25°C
30°C	-25°C	-20°C
40°C	-20°C	-15°C

Table 1: New iStar air cooling performance versus image intensifier size

Notes:

1. **The relationship between the air temperature and the minimum CCD temperature in the table is not 1:1. This is because TE coolers become less efficient as they get colder**
2. **System cooling performance should be considered in terms of the minimum dark current achievable, rather than absolute temperature. For dark current specifications, please refer to the specification sheet for your camera**

2.8.2 - Fan Settings

The cooling fans can be switched On or Off simultaneously, which is useful if working with experimental configurations which are extremely sensitive to vibration. The vast majority of applications, including LIBS or plasma imaging or spectroscopy set-ups, can be used with the integral fans running, since the associated vibrations impact are negligible. However some applications can be extremely sensitive to even the smallest of vibrations (such as when combining an optical set-up with Atomic Force Microscopy - (AFM) and it can be useful to temporarily turn off the fans for the duration of the acquisition.

If the fans are turned off, the usable range of acquisition parameters will be reduced (depending on the ambient conditions) and can limit both the maximum gating frequency and the minimum cooling performance achievable. Once a dataset has been acquired with the fans switched off, it is recommended that they be turned on again and the camera head allowed to thermally re-stabilize (i.e. dissipate the excess heat built up in the heatsinks from both the Peltier cooler and gating circuitry) before the next acquisition can begin.

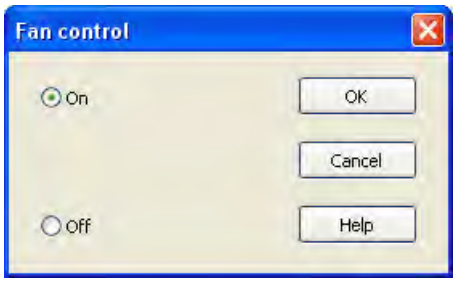


Figure 3: Fan control interface in Solis software.

2.8.3 - Water Cooling

Circulating water is a very efficient method of removing heat from the heatsink. The heatsink temperature will be closely coupled to the temperature of the circulating water and the cooling performance achievable will be dependent upon the water temperature. Water cooling, either chilled though a refrigeration process or re-circulated (i.e. water which has been forced air cooled then pumped) allows lower minimum operating temperatures than air cooling.

The table below is a guide to the minimum CCD operating temperatures for various water temperatures. Performance of individual systems will vary slightly.

Water Temperature	CCD Temperature	
	Ø 18 mm	Ø 25 mm
10°C	-40°C	-35°C
15°C	-38°C	-33°C
20°C	-36°C	-31°C
25°C	-34°C	-29°C

Table 2: New iStar water-assisted cooling performance versus image intensifier size

2.8.4 - Condensation

Condensation may be seen on the outside of the camera body if the temperature of the liquid coolant is too low, or if the coolant flow is too great. The first signs of condensation will usually be visible around the connectors where the water tubes are attached. In such circumstances, system should be switched off and camera wiped with a soft, dry cloth. It is likely there will already be condensation on the cooling block and cooling fins inside the camera. The following actions should be carried out:

- Camera should be set aside to dry for several hours before attempting to re-use
- Dry gas should then be blown through the cooling slits on the side of the camera to remove any residual moisture
- Warmer water or reduced flow should then be used when the device is started again

2.8.5 - Dew Point

The Dew Point graph below plots the relationship between relative humidity and Dew Point at varying ambient temperature. This can be used to calculate the minimum temperature the cooling water should be set to in order to avoid condensation.

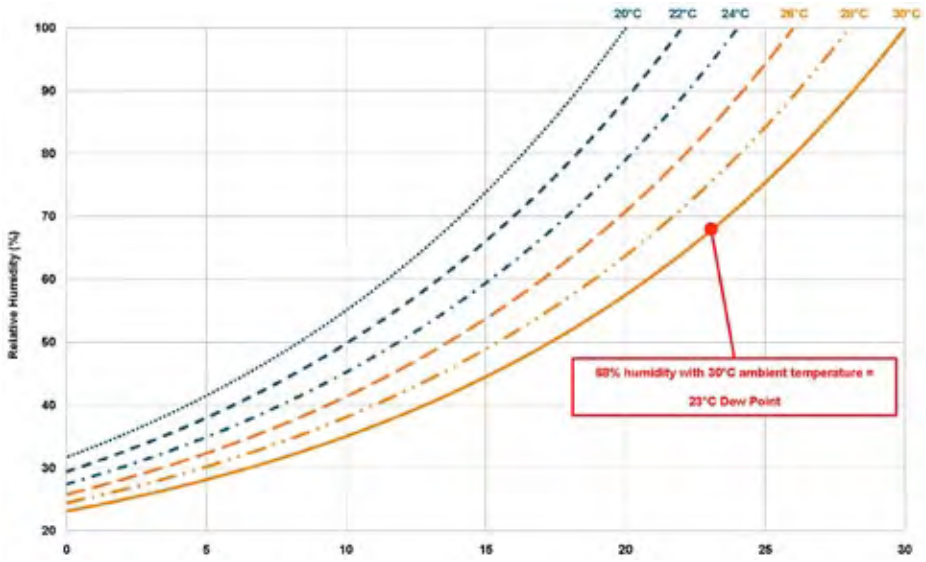


Figure 4: Dew point graph

In the relatively dry atmosphere of an air-conditioned lab, cooling water at 10°C should not present any problems. However, in humid conditions (such as exist in some parts of the world) condensation may occur, resulting in damage to the head. In such conditions you will have to use warmer water (20°C or even higher if it is very humid).

2.8.6 - Water Cooling Accessories

A chiller or a re-circulator unit can be used to achieve maximum cooling performance with the camera system. These units circulate coolant through hoses connected to the coolant channel within the camera head.

Please refer to the New iStar specification sheets for further details and ordering information.

2.9 - CONNECTORS

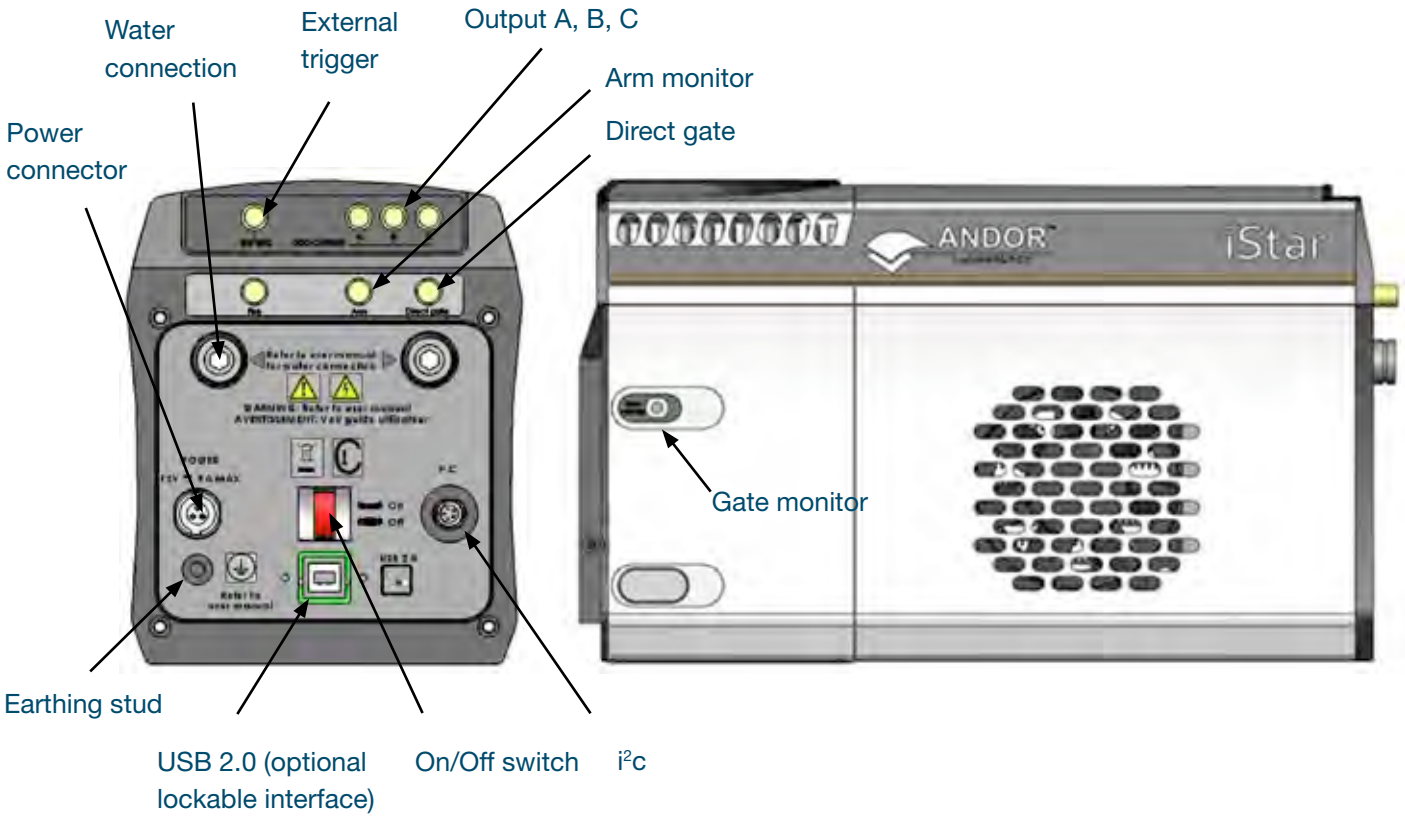


Figure 5: Rear & side views showing connectors interface

The user can synchronize the readout of the New iStar camera to external events / equipment by means of the SMA receptacles. The functions of each are detailed below:

- **Ext Trig (External Trigger)**: TTL compatible input which is used to initiate data acquisition by the camera
- **Digital Delay Generator Outputs A, B & C:** Programmable 5V CMOS level outputs used to synchronize external events / equipment with operation of the New iStar
- **Fire:** 5V CMOS level reference signal relating to the CCD exposure time. This output remains high during the charge / signal accumulation period, i.e. the time during which charge from the image area is not being read-out
- **Arm:** 5V CMOS level reference signal to indicate when system is ready to accept external triggers. Signal goes high when system is ready to accept external triggers after a readout sequence has finished, and goes low when the exposure is finished
- **Direct Gate:** TTL compatible input used to directly gate the photocathode of the image intensifier tube, i.e. switch it On and Off. The photocathode is On when the input is high. User should provide (electrical) pulse width and appropriate gate pulse delay
- **Gate Monitor:** Enables user to monitor the accurate, actual On and Off switching of the photocathode

The other connection points are as follows:

- **USB 2.0:** A USB 2.0 compatible cable can be connected between the USB socket and a PC. Optional locking connection is also available
- **I²C**: The user can communicate with other I²C devices by means of the 5-way receptacle (Fischer P/N DBP 102 A 054 – 130) on the rear of the New iStar. The pin-out of this connector is shown below:

Pin	Function
1	SHUTTER (TTL)
2	I²C CLOCK
3	I²C DATA
4	+5 V
5	GROUND

Table 3: I²C connection (facing in) with pin-outs

- **Power:** A 3-pin power connector is fitted for power connection, with the following pinout:

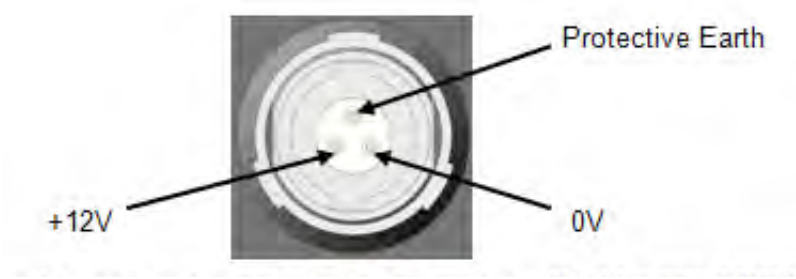


Figure 6: Power connector pin-outs. Matching cable connector is 3-pin Redel no. PAH.N0.3GL.LC65G

- **Earthing stud:** Means of providing protective earth connection to camera head when it is not, or cannot be provided via the 3-pin power connector

Before inserting the power connector, ensure that the orientation is correct. Never forcibly insert the connector, otherwise damage to the equipment will occur.

2.10 - POWER SUPPLY UNIT (PSU)

The New iStar system is designed to be powered from an SW4189 external PSU (Andor P/N PS-90) as shown below. This requires an AC mains input between 100-240 V, 47-63 Hz and a maximum supply current of 1.6A. The output of the SW4189 is 12V DC at 9.0A maximum. The SW4189 PSU is fitted with an IEC connector for the electrical supply input. The connection to the New iStar is made via a 3 pin Redel cable plug (Part No. PAH.N0.3GL.LC65GZ).

Figure 7: PS-90 power supply for the New iStar

Important notes:

1. **The electrical mains lead should be certified for in the country of use and when applicable the plug must be fitted with a 240 V 5A fuse**
2. **If users use any other power supply, they do so at their own risk**
3. **The SW4189 is for use with telecommunications, computer, industrial controllers & OA systems, and must only be used indoors**
4. **The PS-90 is the only external power supply recommended for use with the New iStar camera. If this unit fails or is damaged, the local Andor representative should be contacted for a replacement.**

2.11 - FUSE REPLACEMENT

The camera itself does not have a fuse. However, if a U.K. (BS 1363) mains lead has been supplied, it contains a fuse, whose characteristics are as follows:

- **Rated Current:** 5 A
- **Rated Voltage:** 240 Vac.
- **Type:** BS 1362
- **Size:** 0.25 × 1 inch

2.12 - ADDITIONAL OPTIONAL ACCESSORIES

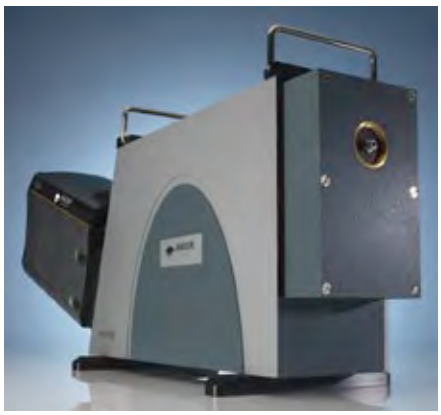
A lens (instead of a spectrograph) may be connected to the ICCD detector for imaging applications. The following items are recommended for connection of standard lens types:

- C-Mount Lens Adaptor Kit (P/N LM-C), comprising C-mount adaptor, spacer tubes, screws & allen key.
- Nikon F-Mount Lens Adaptor (P/N LM-NIKON-F)
- Nikon F-mount adaptor with shutter (P/N LMS-NIKON-F-NS25B)

Note: Although ICCDs efficiently act as optical shutters, the use of a mechanical shutter is recommended when camera is not used to protect the photocathode from "passive" photo-bleaching.

2.13 - SPECTROGRAPH COMPATIBILITY

The New iStar series is also fully compatible with Andor's Shamrock spectrograph (163, 303, 500 and 750 mm focal lengths) family and Mechelle 5000, Echelle spectrograph for broadband LIBS.



Spectrograph mounting flanges and software control are available for a wide variety of 3rd party spectrographs including, McPherson, JY/Horiba, PI/Acton, Chromex/Bruker, Oriel/Newport, Photon Design, Dongwoo, Bentham, Solar TII and others. Please contact your local representative for further details.

2.14 - SOFTWARE

If ordered, Andor Solis Software or Andor Software Development Kit (SDK) is supplied on a CD and provides full control of the New iStar camera system, including acquisition set-up, signal aquisition and data manipulation.

Solis and SDK provide simultaneous control of the Andor New iStar, Andor Shamrock and Andor Mechelle as well as a range of 3rd party motorized spectrographs.

For further details of how to use the Solis software package, please refer to **Section 4.**

SECTION 3 - INSTALLING THE NEW ISTAR

Prior to commencing installation, user should refer to the safety and warning information at the beginning of this manual.

3.1 - MECHANICAL CONNECTION TO THE NEW ISTAR

3.1.1 - Attaching to a Spectrograph

The New iStar can be easily connected to Andor's **Shamrock spectrograph.** If the New iStar and Andor's spectrograph have been ordered at the same time, the system will arrive already pre-aligned and integrated. Outside this scenario - including matching the New iStar to a third-party spectrograph - the following generic instructions should be followed:

1. Bolt the **detector** to the **camera mounting flange**, ensuring that the head is correctly orientated and that the appropriate **O-ring** is inserted at the front of the detector head.
2. Attach the **camera mounting flange** to the spectrograph, ensuring that the appropriate **O-ring** is in place between both detector flange and spectrograph flange.
3. Secure all four attachment screws so that the detector head, the flanges and the spectrograph are fitted together securely in order to allow correct grounding through the connector cable. Good grounding maintains the low noise performance of the detector, and in severe environments may prevent the instrument from damage.

3.1.2 - Attaching to a Lens System

The Andor New iStar can also be easily connected to a **lens system** for imaging purposes. Andor local representative can supply details of the available adaptors for connecting the **detector head** to various manufacturers' lenses. The following general instructions should be followed:

1. When attaching the New iStar to a **lens adaptor** (C-Mount or F-Mount for example), ensure first that the adpater is correctly orientated and aligned. Ensure that the appropriate **O-ring** is inserted between the camera front plate and the **lens adaptor** plate. In the case of the C-Mount, place the side of the adaptor that is flush with the brass insert towards the New iStar front plate. Ensure that all four attachment screws are secured to the adaptor.
2. Attach the appropriate lens into the brass insert (C-Mount) or bayonnet interface (F-Mount) of the lens adaptor.

3.1.3 - Attaching to Nounting Posts

THREE ¼ -20 UNC THREADED HOLES ARE LOCATED ON THE UNDERSIDE OF THE UNIT. DRAWING IN SECTION 2.2 PROVIDES PRECISE LOCATION OF THESE MOUNTING HOLES.

3.2 - COOLANT HOSE INSERTS

Two barbed coolant hose inserts are supplied as standard with the New iStar camera, suitable for connection to 6 mm (0.25”) internal diameter soft PVC tubing / hose. The recommended tubing should have 10 mm (0.4”) outside diameter, i.e. a wall thickness of 2 mm (0.08”). Alternative hose dimensions and materials should be thoroughly tested to ensure a leak tight seal is achieved with the barbed inserts. Once the hose has been secured to the barb, connection to the camera is achieved by clicking hose inserts into the quick-release couplings on the rear of the camera head.

Before attempting to remove the hose connection, user should ensure that all water has been drained from the hoses and integral coolant channel within the camera head. Care must be taken to avoid permanent damage to the camera system resulting from either leakage of coolant during connection / removal of hoses or spillage of any residual coolant contained within the camera head once the hoses have been removed.

Removal of the coolant hoses is achieved by slightly pulling the barbed connector, whilst at the same time depressing the collar on the quick-release couplings, which releases the hose insert as shown below:

Figure 8: Removal of coolant hose inserts from quick release couplings on camera head

Some mains supply water are heavily mineralized, (i.e. “Hard”) which could cause deposits in the water circuit inside the camera. This can reduce the flow-rate and affect the cooling preformance. It is therefore recommended to use de-ionized water (without additives) as the coolant.

The specified cooling performance of the camera can be achieved with coolant flow rates of 0.75 litres per minute, and the maximum recommended pressure of coolant circulating through the camera head is 2 bar.

In the event that replacement hose inserts / barbs are required, the local Andor representative should be contacted.

Important note: The temperature of liquid coolant circulated through the camera head should always be above the dew point. Use of coolant at or below the dew point will result in permanent damage to the camera head, due to formation of condensation on internal components. Section 2.8.5 provides further details on this point.

3.3 - ELECTRICAL CONNECTIONS

Prior to applying any power or triggering signals to the camera. The following recommendations should be followed:

- As part of the safety features of the New iStar system, the product is designed to have a protective earth connected via the earth pin on the mains plug supplying the SW-4189 (PS-90). It is important to ensure that this is connected to the buildings protective earth system, independently of the earth used for electrically noisy instruments such as pulsed lasers.
- When a protective earth is **NOT** provided to the camera head through the 3-pin power connector, the earthing stud on the rear of the New iStar camera head **MUST** be connected to the buildings protective earth system. The gauge of cable used for this connection must be 20 AWG or lower (i.e. wire diameter ≥ 0.812 mm).
- The equipment should be positioned in such a way that the mains supply plug/cord can be easily accessed for disconnection.
- Section 2.9 to should be used to identify correctly the plug location for the different interfaces, including power, i^2c as well as the comprehensive input / output connections
- Prior to connecting the USB cable to the PC or laptop, software and USB driver installation instructions in Section 3.4 should be followed.

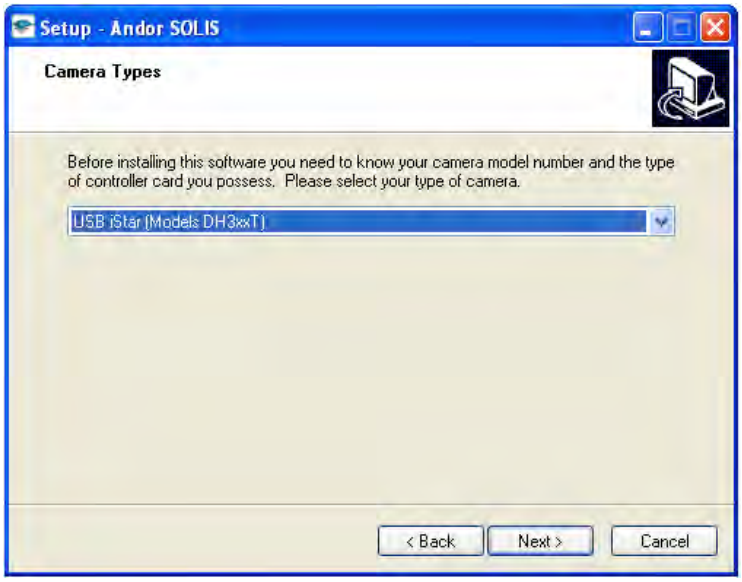
3.4 - INSTALLING SOFTWARE AND USB DRIVERS

3.4.1 - Minimum Computer Requirements

- 3 GHz Quad Core or 2.4 GHz multi core processor
- 2 GB RAM
- 100 MB free hard disc to install software (at least 1 GB recommended for data spooling)
- USB 2.0 High Speed Host Controller capable of sustained rate of 40 MB/s
- Windows (XP, Vista or 7) or Linux

3.4.2 - Installing Solis Software and USB Driver

1. Terminate & exit any programmes which are running on the PC.
2. Insert the Andor Solis CD. The InstallShield Wizard should now start. If it does not start automatically, run the file setup.exe directly from the CD.
3. Select appropriate location for installation of software and drivers on your computer / network.
4. When prompted, select New iStar as shown below.



5. Continue installation and restart your computer - when prompted - to successfully complete the installation.
6. The shortcut icon for Solis will appear on the desktop on re-start.
7. The New iStar is now ready to be connected to a PC / laptop and powered on.

3.4.3 - New Hardware Wizard

When the New iStar camera is connected to a PC for the first time, the **Found New Hardware Wizard** screen will appear.

1. Select the '**No, not this time only'** option then click **Next>** .
2. Select the **'Install from a list or specified location (Advanced)** option then click **Next**>.
3. Navigate to the directory where the Andor Solis software was installed to on the PC, then click **Next> so that the Installation Wizard can start.**
4. When the hardware installation has been completed, the following screen will appear.

5. Click the **Finish** button to complete the installation.

Note: If the camera is connected to a different USB port, steps 1 – 5 will have to be repeated on the first connection only.

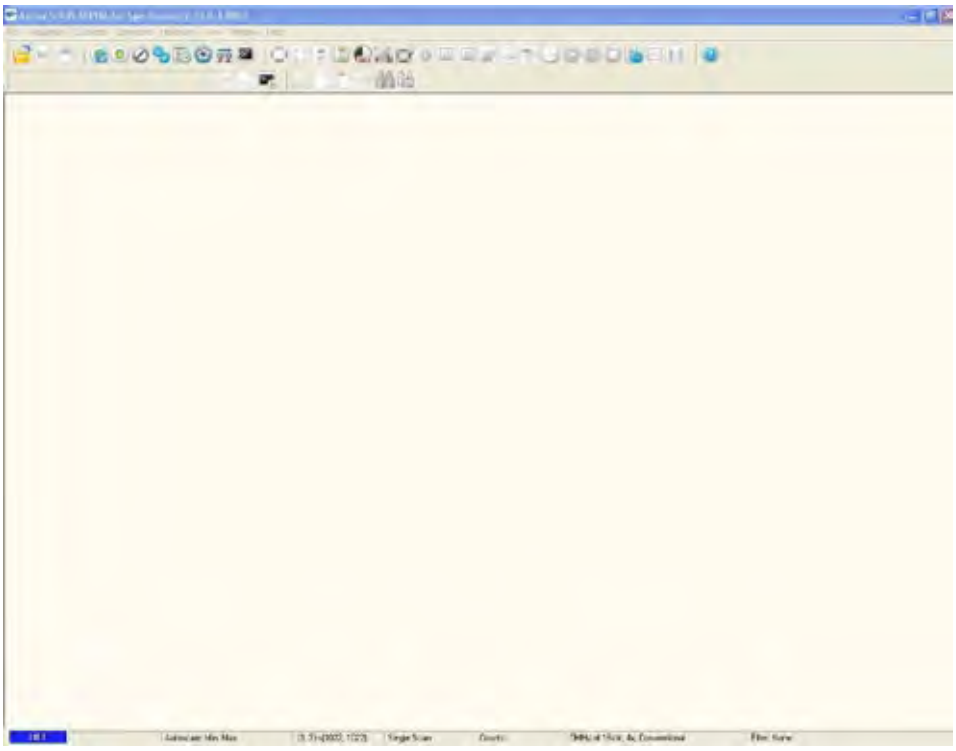
6. Check that the New iStar is correctly recognized and installed by opening the Device Manager in Windows, System Properties section. The New iStar will be showing under the LibUSB root, as highlighted below:

SECTION 4 - SOLIS SOFTWARE OPERATION

4.1 - STARTING THE APPLICATION

On the computer / laptop desktop, click on the icon. The following **Solis splash screen** appears:

The **Main Window** then appears, e.g.:



4.2 - MAIN WINDOW

The Main Window is the user 'entry point' to the system. The menu options allow the user to either execute specific functions directly, or launch further windows/dialog boxes to access more comprehensive functionalities. Some menu options on the Main Window are also accessible through quick-launch buttons, as shown in the table below:

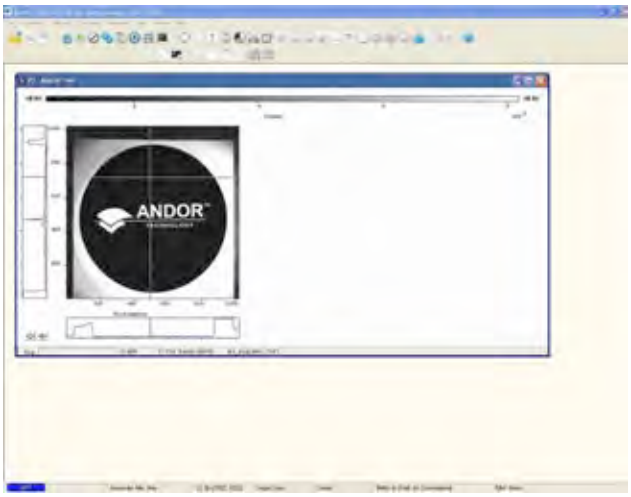
ICON	TITLE	ICON	TITLE	ICON	TITLE
	Open file / program		Select sub-image area		Image display mode
	Print		Select autoscale area		Change display color palette
	Save		Reset scale		Time stamp settings
	Real-time acquisition		Rescale data		Play kinetic series sequence
	Take signal		Acquistion autoscale (live window)		Pause kinetic series sequence
	Abort acquistion		99 to 1 contrast ratio adjustment		Stop kinetic series sequence
	Setup acquisition		Data histogram display		Playback autoscale - Off
	Run-time control		Region of interest settings		Baseline correction
	Shutter control		File information		Periodic table
	Spurious noise filter		2D display mode with peak labels		Temperature control - Off
	Run program		2D display mode		Temperature control - On
	Command line		3D display mode		Help

Table 4: Main window quick-launch buttons

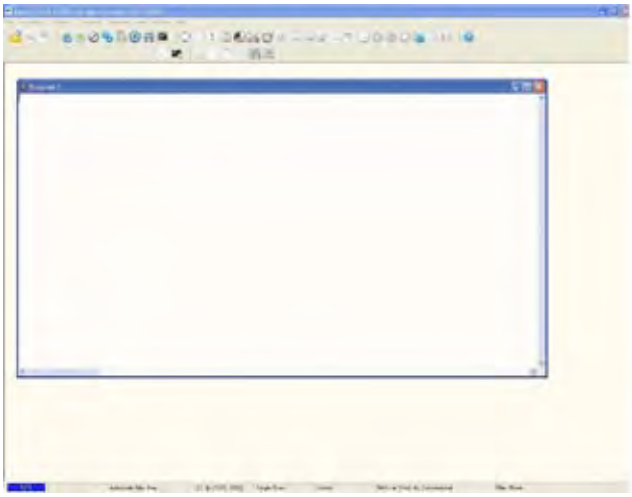
Note: Some menu titles and buttons appear on the Main Window only under certain circumstances as shown on the next sections.

Note: Icons are grouped by functionalities on dynamic display bars, which can be enabled / disabled through the View menu.

- The Display menu and its associated buttons will not appear until you open a Data Window is opened, e.g.:



- The Edit & Search menus and their associated buttons appear only when a Program Editor Window is active, e.g.:



4.2.1 - Main Window Status Bar

The following information is displayed on the bottom line of the display:

- Current temperature status
- Autoscale acquisition status
- Sub-area dimension and location
- Acquisition mode
- Data type
- Readout speed, No of bits and amplifier in use

4.3 - HOT KEYS

Hot keys (or shortcuts) are shown in the following tables, enabling user to work with the system directly from the keyboard.

KEY STROKE(S)	DESCRIPTION
F5	Take signal
F6	Autoscale acquisition
Ctrl + B	Take background
Ctrl + R	Take reference
Esc	Abort acquisition

Table 5: Data acquisition Hot Keys

		DISPLAY MODE		
KEY STROKES	DESCRIPTION	2D	3D	IMAGE
+	Expand ('Stretch') data-axis	✓	✓	✓
-	Contract ('Shrink') data-axis	✓	✓	✓
Ins	If maintain aspect ratio off, expand x-axis. If maintain aspect ratio on, expand x-axis and y-axis	✓	✓	✓
Del	If maintain aspect ratio off, contract x-axis. If maintain aspect ratio on, contract x-axis and y-axis	✓	✓	✓
/	On image, if maintain aspect ratio off, expand y-axis. On image, if maintain aspect ratio on, expand x-axis and y-axis.			✓
Home	Move cursor furthest left	✓	✓	✓
End	Move cursor furthest right	✓	✓	✓
PgUp	Scroll up through track	✓	✓	✓
PgDn	Scroll down through tracks	✓	✓	✓
Shift + PgUp	Move to next image in series	✓	✓	✓
Shift + PgDn	Move to previous image in series	✓	✓	✓
Left Arrow	Move cursor left	✓	✓	✓
Right Arrow	Move cursor right	✓	✓	✓
Up Arrow	Scroll trace up (on image: move cursor up)	✓	✓	✓
Down Arrow	Scroll trace down (on image: move cursor down)	✓	✓	✓
Shift + Left Arrow	Scroll trace/image left	✓	✓	✓
Shift + Right Arrow	Scroll trace/image right	✓	✓	✓
Ctrl + Left Arrow	Peak search left	✓	✓	✓
Ctrl + Right Arrow	Peak search right	✓	✓	✓
F7	Toggle Palette	✓	✓	✓
F8	Reset	✓	✓	✓
F9	Rescale	✓	✓	✓
Alt + F9	Toggle Rescale Mode	✓	✓	✓
Ctrl + F9	Scale to Active (see Section 4 - Displaying Data) section)	✓	✓	✓
F10	File information			

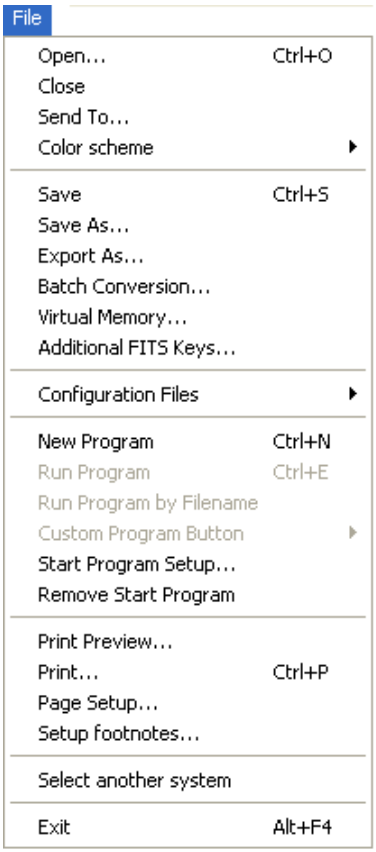
Table 6: Data window Hot Keys

KEY STROKE(S)	DESCRIPTION
Ctrl + N	New program
Ctrl + E	Run program
Esc	Abort acquisition / program
Ctrl + L	Command line
Ctrl + F1	Context sensitive help on reserved words in the Andor Basic programming language. (Program Editor Window must be active).
Ctrl + S	Save
Ctrl + P	Print

Table 7: Andor Basic Programming Language Hot Keys

4.4 MENU SELECTION

4.4.1 File Menu



Open: Opens a selected data file or program file

Close: Closes a selected data file or program file

Send To: Allows user to send selected sif or program files by e-mail

Color scheme: Setup of alternative color for **background, acquisition window, data set or program window**

Save: Saves a selected data file or program file with a default (or current) filename

Save As: Saves a selected data file or program file with a user-defined filename

Export As: Allows user to export sif files to alternative formats (e.g. JPEG, TIFF)

Batch Conversion: Allows simultaneous conversion of large batches of data files from a specified location to a particular format and a specified location

Virtual memory : Presets the disk storage system memory buffer size for extended kinetic acquisitions

Additional FITS Keys: Allows addition of user's own FITS information

Configuration Files: Loads or saves custom acquisition mode settings

New Program: Launches a program editor window for Andor Basic

Run Program: Runs Andor Basic program in active window

Run Program by Filename: Runs an Andor Basic program from a specific location

Custom Program Button: Adds or removes button shortcut for specific Andor Basic programs

Start Program Setup: Allows automatic loading of Andor Basic program from a specific location on Solis software launch

Remove Start Program: Deactivates automatic program loading on Solis software startup

Print Preview: Allows preview of a sif or program file prior to printing

Print: Prints a selected sif or program file

Page Setup: Allows setting of document printing characteristics

Setup footnotes: Allows setting of footnotes associated with data file to be printed

Select another system: Allows toggling between several Andor detectors connected to the current PC / laptop platform

Exit: Exits the Solis software

4.4.2 - Acquisition Menu

The **Acquisition** drop-down menu provides the following options:

Setup Acquisition: Allows user to set-up the CCD & Intensifier acquisition parameters

Setup Data Type: Allows user to select the data windows X-axis unit display

Notify On Completion: Allows user to either start an application (.exe file) or play a user-defined sound on completion of an acquisition sequence

Take Signal: Starts a data acquisition based on the current CCD & Intensifier acquisition parameters

Take Background: Instructs the system to acquire raw background data based on predefined shutter or image intensifier settings

Take Reference: Instructs the system to acquire reference signal from external (light) source

Abort Acquisition: Stops the existing acquisition sequence

Autoscale Acquisition: Configures the acquisition window to scale automatically during acquisition sequence when selected ('✓')

Temperature Warnings: Displays any messages associated to setups or processes incompatible with the standard operation of the temperature control e.g. starting acquisition while sensor is still cooling down - only active when selected ('✓')

Selecting the **Setup Acquisition** menu brings the following interfaces which will be described and detailed throughout **Section 5**.

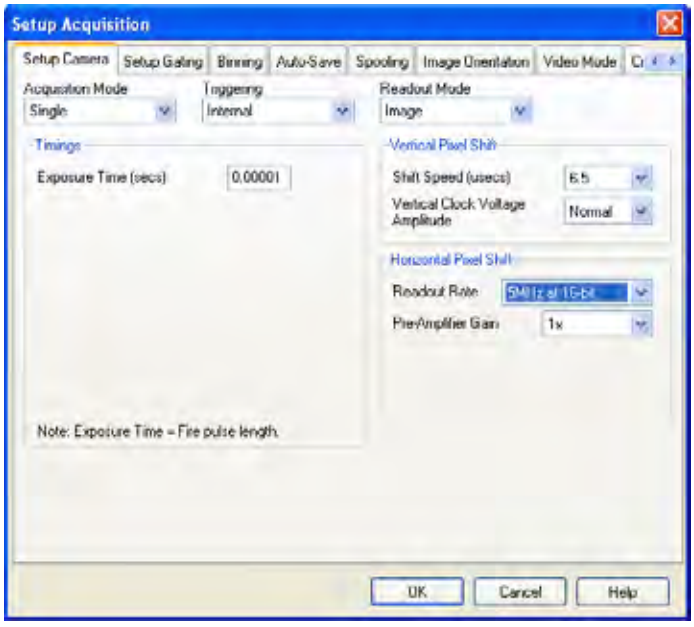


Figure 9: CCD setup tab

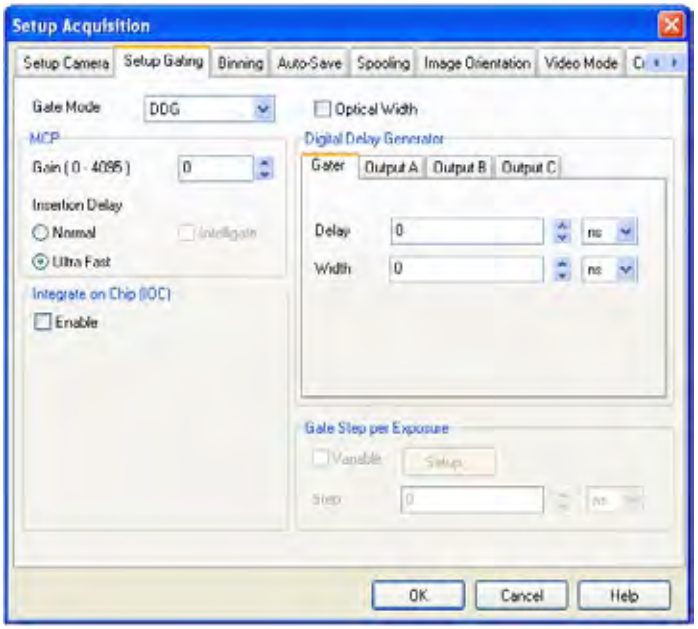
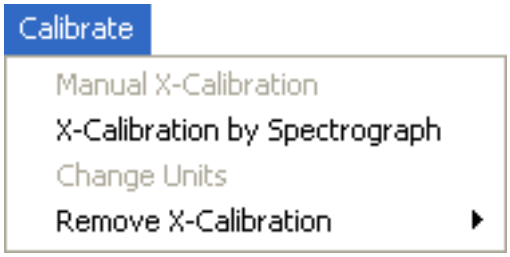


Figure 10: Gating setup tab

4.4.3 - Calibrate Menu

The Calibrate drop-down menu provides the following options:



Manual X-Calibration: Allows users to calibrate the x-axis of the active data window through manually setup values

X-Calibration by Spectrograph: Allows user to calibrate the x-axis of the active data window via specific dispersion calibration from a spectrograph (see screenshot below)

Change Units: Allows user to change the x-axis units of an active data window which has been previously calibrated e.g. cm^{-1}, nm or eV

Remove X-Calibration: Allows user to remove any calibration previously applied to a data window

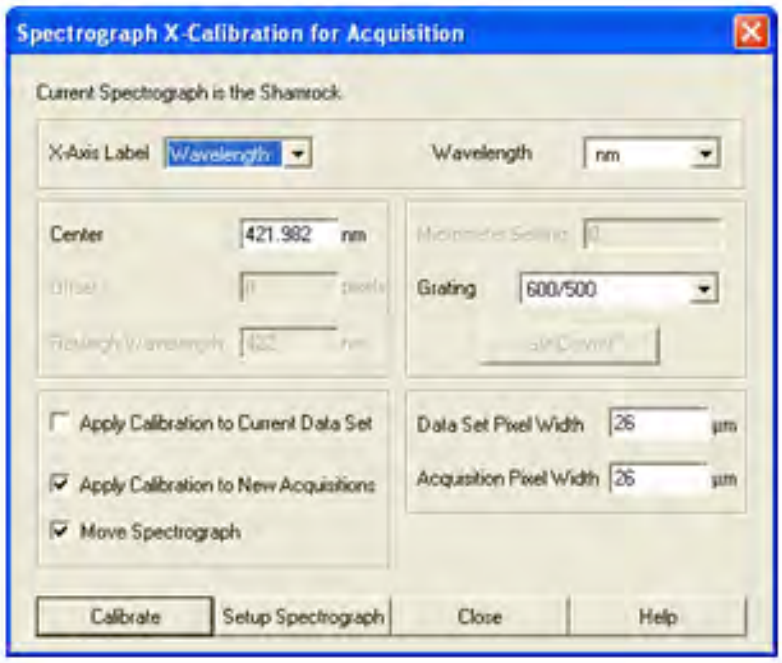
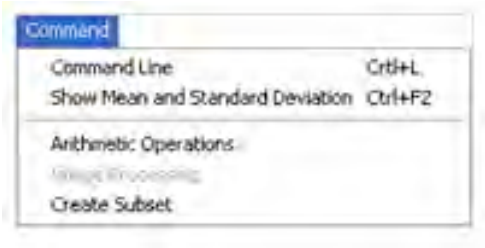


Figure 11: X-Calibration by Spectrograph interface

Spectrograph setup and calibration will be detailed in **Section 8**

4.4.4 - Command Menu

The Command drop-down menu provides the following options:



Command Line: Opens a dialog box to allow user to input one-line commands written in Andor Basic programming language

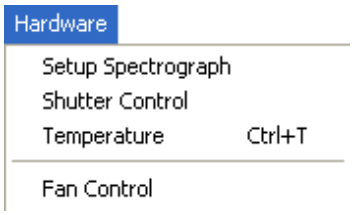
Show Mean and Standard Deviation: Displays mean signal value and/or standard deviation from mean in the data windows header

Arithmetic Operations: Allows basic arithmetic data manipulation e.g. addition, subtraction etc.

Note: Please also refer to the Andor Basic programming and Help sections.

4.4.5 - Hardware Menu

The Hardware drop-down menu provides the following options:



Setup Spectrograph: Allows user to select, setup and load calibration for the spectrograph being used, in conjunction with the Andor detector

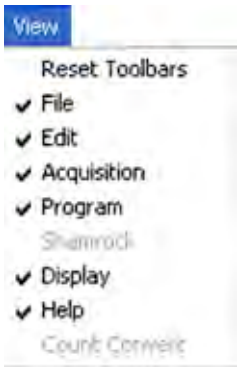
Shutter Control: Allows user to setup the appropriate shutter mode of operation, synchronization and delays

Temperature: Allows user to setup the cooling temperature of the sensor

Fan Control: Allows user to switch the cooling fans (CCD and gater) On or Off

4.4.6 - View Menu

The View drop-down menu allows user to enable or disable quick-access icon bars display on the main Solis window, as well as reset the display of these icon bars to a default arrangement:



4.4.7 - Display Menu

The Display drop-down menu provides the following options:

Change Display Mode: Allows user to change the display mode (2D, 3D or Image) of the acquired data

Add Data Window: Allows user to duplicate an active window data in a new window with display mode of choice, i.e. 2D, 3D or Image

Preferences: Allows user to optimize display interface e.g. peak labelling and 2D/3D graphical display

Axis Setup: Allows user to select data display range and units

Sequence options: Allows user to playback kinetic series acquisitions from a set of custom parameters

Rescale Data Mode: Allows user to select the display range of the data intensity

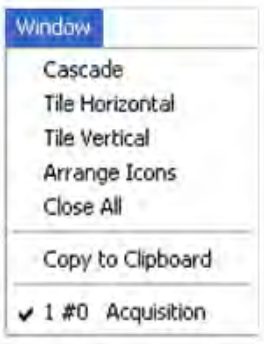
Data Histogram: Allows user to plot a histogram showing the signal data intensity versus number of pixels holding the same intensity value

Scale to Active: Allows overlaid signal traces to be rescaled to the active set of data range

Region of Interest: Allows user to define a specific area of interest (ROI) in an acquisition window

4.4.8 - Window Menu

The **Window** drop-down menu provides the following options:



Cascade: All data windows appear overlaid and offset within the Solis software frame

Tile Horizontal: Arranges selected data windows along the horizontal direction within the Solis software frame

Tile Vertical: Arranges selected data windows along the vertical direction within the Solis software frame

Close All: Closes all currently opened data windows

Copy to Clipboard: Copies the active data set into Windows clipboard for pasting to a particular program, e.g. Word, Paint etc.

4.4.9 - Help Menu

The Help drop-down menu provides the following options:

Solis Help: Opens the Andor Solis Help dialog

Andor Basic Help: Opens the Andor Basic Help dialog

Shamrock Help: Opens the Andor Shamrock spectrographs Help dialog (if available)

About: Provides information on the Solis version number

About LibTIFF: Provides information on the TIFF library version integrated in Solis

4.4.10 - Software Help

The Andor Solis software provides on-line help based on the same format as typical of Windows applications.

When the application is running, click the button or press **F1** key should used to access the Andor Solis help dialog.

In addition to the main on-line help, the system provides help that relates specifically to the **Andor Basic** programming language. When working with a Program Editor window, context sensitive help is available on the 'reserved words' of the programming language. With the cursor on or immediately after a reserved word, this specific help can be accessed by **Ctrl + F1.**

If you have any suggestions as to how our software, hardware and documentation might be improved, please let us know by contacting your local Andor representative **(see Section 1.3)**.

4.5 - RUN-TIME CONTROL

The run time control provides the user with the ability to control the following parameters in real-time using slider controls:

- CCD exposure time
- Gating mode
- Gate width and delay
- MCP gain
- Output A, B and C delay and width

The controls are activated by clicking the button on the main window. When selected, the run time control appears, e.g.:

4.6 - ANDOR BASIC

Solis contains an embedded programming language called Andor Basic that can be used to setup custom acquisition sequences. For example to run a sequence of 100 single scans with a 1 second delay between each scan, the following program can be used:

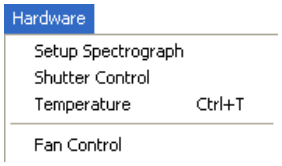
```
create(#1, detectorx(), detectory(), 100)   //creates a dataset #1 large enough to store all images
setkineticnumber(1)                         //takes one image each time the loop iterates
for i = 1 to 100
run()                                       //acquires an image
#1{i} = #0{1}                               //copies the acquired data from the #0 acquisition window to a location in #1
delay(1000)                                 //waits for 1000 milliseconds before progressing
next
```

Note: Documentation on the Andor Basic programming language is accessed via the Help menu in the main application window

SECTION 5 - PRE-ACQUISITION SETUP

5.1 - SETTING TEMPERATURE

For accurate readings, the detector should first be cooled, as this will help reduce dark signal and associated shot noise. To do this, either select the **Temperature** option from the **Hardware** drop-down menu on the main window:



or click the button in the bottom-left of the screen. This will open up the **Temperature** dialog box :

Select the **On** radio button in the **Cooler** area.

The degrees (C) field in the Temperature Setting section will now be highlighted in blue and the Cooler will be indicated as On, e.g.:

To adjust the temperature, either type in the new figure in the Degrees (C) box or move the slider bar down or up. Once the desired temperature has been selected, click OK. The dialog box will disappear and the Temperature Control button in the bottom-left of the screen will show the current temperature highlighted in red e.g.:

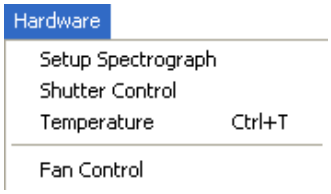
This figure will change as the head cools. Once the head has reached the desired temperature, the highlighted area changes to blue.

You can also select the option to have the Cooler switched on as soon as you start the application. This is selectable in the bottom-left of the Temperature dialog box.

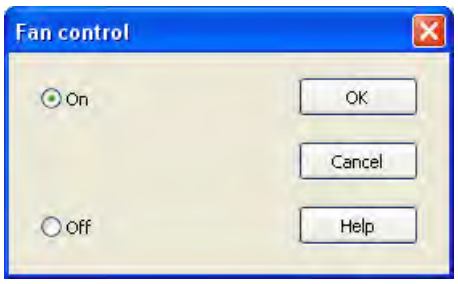
Note: Please refer to Section 2.8 for details on minimal achievable temperatures

5.2 - FAN CONTROL

The state of the cooling fan can also be controlled. Select Fan Control from the Hardware drop-down menu as shown:



The Fan control dialog box will appear:

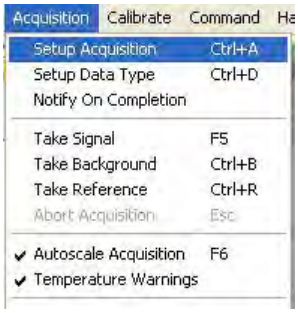


Select whether fans should be activated or deactivated during cooling and/or acquisition.

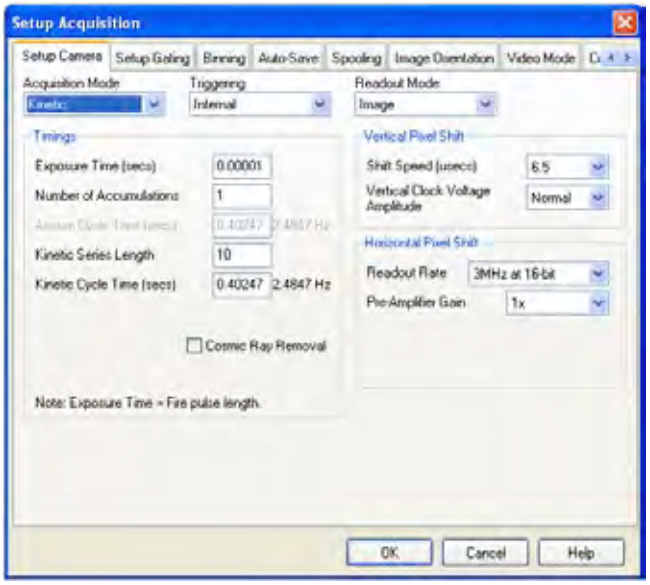
5.3 - CCD SETUP ACQUISITION

To select the mode of acquisition prior to data capture, the following steps should be followed:

- Click the button
- Key in **Ctrl+A**
- Select **Setup Acquisition** from the **Acquisition** drop-down menu:



The Setup Acquisition dialog box appears, e.g.:



As user selects an acquisition mode, additional acquisition-related parameter fields will appear. The following matrix lists the acquisition modes and the key set-able parameters:

MODE	EXPOSURE TIME	ACCUMULATE CYCLE TIME	NO. OF ACCUMULATIONS	KINETIC CYCLE TIME	NO. IN KINETIC SERIES
Single Scan	✓				
Accumulate	✓	✓	✓		
Kinetic	✓		✓	✓	✓

Note: The value entered in one field (e.g. exposure time) may affect the value in another field (e.g. acquisition cycle time)

Note: Other modes such as photon counting or fast kinetics will be detailed specifically in following sections of this user guide

5.3.1 - Acquisition Modes & Timings

An acquisition is taken to be the complete data capture process that is executed whenever user selects **Take Signal**, **Take Background**, or **Take Reference** from the acquisition menu, or whenever user clicks the **Take Signal** button. By contrast, a scan (an “acquired scan” in the definitions that follow) is a single readout of data from the CCD-chip. Several scans may be involved in a complete data acquisition. The minimum time required for an acquisition is dependent on a number of factors, including the exposure time (i.e. the time in seconds during which the CCD collects light prior to readout) and the triggering mode. Triggering modes are described in more detail later in this section.

5.3.1.1- Single Scan

Single scan is the simplest acquisition mode, in which the system performs one scan of the CCD.

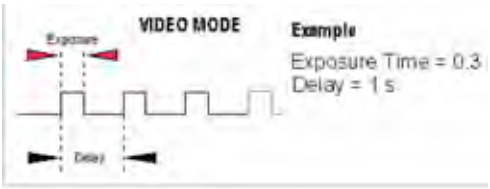
The following parameters can then be changed:

- **Exposure Time**

Note: Should user attempt to enter too low a value, the system will default to a minimum exposure time.

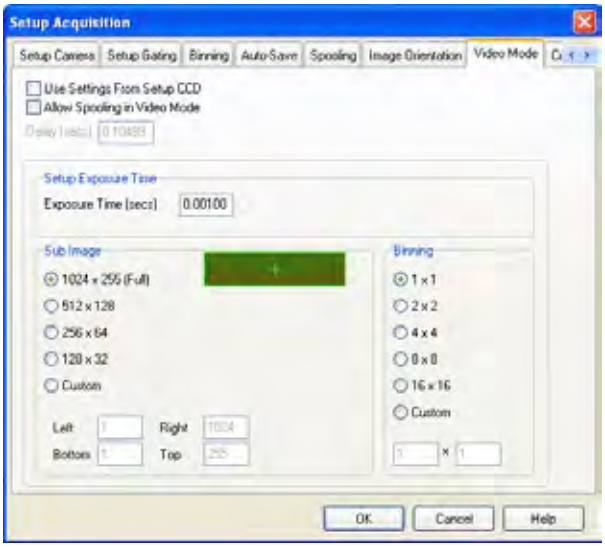
5.3.1.1.1 - Video

If user selects the button, the system repeatedly performs a single scan and updates the data display.



Note: This is a useful mode for focusing the New iStar and for watching experimental events happening in real time. However, this mode will not allow to save any of the acquired images or data, except for the last frame of the sequence.

When the **Video Mode** tab on the setup acquisition dialog box is selected, the video mode dialog interface appears, e.g.:



The following parameters can then be set:

- **Exposure Time**
- **Delay:** The interval required between scans.
  Note: When entering too low a value, the system will default to a minimum delay
- **Resolution (sub-image area):** Size of the sub-image (in pixels)
- **Binning pattern:** Super pixel size (in pixels)

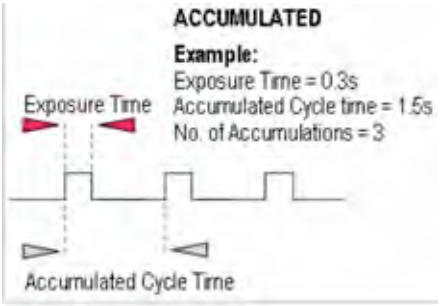
Note: When the 'Use Settings From Standard Setup' option is selected, these parameters cannot be altered.

The system will acquire data only as quickly as these can be displayed. If **Take Background** or **Take Reference** in video mode are the chosen mode of operation, the system will perform one scan only. New data will continue to be acquired and displayed until one of the following actions is being carried out:

- Select **Abort Acquisition** from the **Acquisition Menu**
- Click the button
- Press the **<ESC>** key

5.3.1.2 - Accumulate

Accumulate mode allows user to 'add together' in the computer memory the data from a number of scans to create an 'accumulated scan' e.g.:



The following parameters can be entered in the **Setup Acquisition** dialog box:

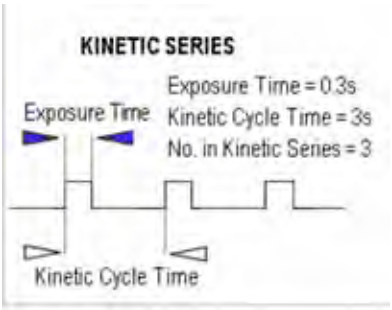
- **Exposure Time**
- **Accumulated Cycle Time**: The period in seconds between each scan. This parameter is only available when internal triggering is selected
- **No. of Accumulations**: The number of scans to be added together

Note: This mode can be used to effectively improve the acquisition signal to noise ratio.

5.3.1.3 - Kinetic Series

Kinetic series mode allows user to run, record and save a sequence of consecutive acquisitions in a single working window. The following parameters are used to configure the acquisition:

- **Exposure Time**
- **Kinetic Cycle Time:** The time between the start of two consecutive scans within a kinetic series
- **Number in Kinetic Series:** The number of scans taken in the kinetic series



This mode is particularly well suited to recording the temporal evolution of a process, and can also be used in conjunction with accumulation mode for further signal-to-noise ratio enhancement

Note: If External trigger is selected the Kinetic Cycle dialog box will indicate the maximum achievable frame rate.

5.3.1.4 - Fast Kinetics

Fast Kinetics mode allows access to exposure times (and time resolution) on a microsecond timescale, i.e. in the order of magnitude of the CCD vertical shift speeds. However, in the case of ICCDs, the ultimate time-resolution will be dictated by the photocathode gate time.

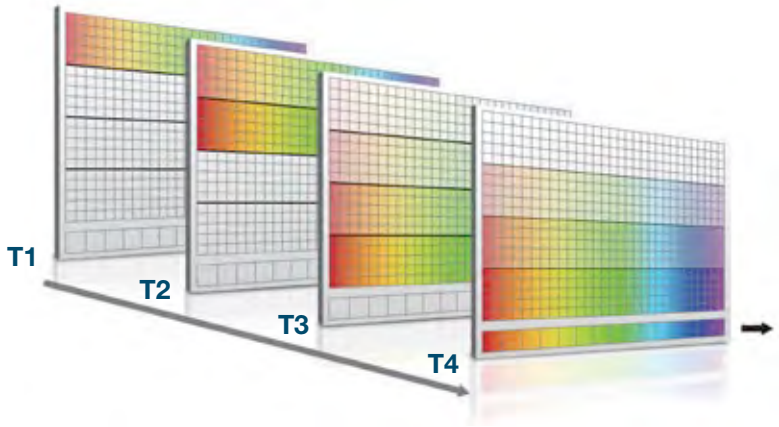
In Fast Kinetics the signal to be recorded is imaged across a certain section of the CCD, typically across the top rows of the CCD sensor. The non-illuminated part of the CCD is used for storage of the consecutive images part of the same acquisition sequence before readout. The overall sequence is recorded in one single acquisition window.

T1 - CCD keep clean sequence is interrupted, and useful signal builds-up on the user-defined top portion of a sensor

T2 - At the end of the exposure time, signal is rapidly shifted down by a pre-defined number of rows, and a second exposure takes place

T3 - This process is repeated until the number of acquisitions equals the series length set by user

T4 - The sequence moves into the readout phase by shifting in turn the individual acquisitions to the readout register, which is then read out



From the **Setup Acquisition** dialog box, the following parameters can be configured:

- **Exposure time:** the exposure time also represents the cycle time of the Fast Kinetics series. There is no separate parameter for a fast kinetics cycle time
- **Sub Area Height** in rows
- **Number in Series:** the number of time-sampled acquisitions in the series to be stored on the sensor. These will depend on the sensor height and number of active rows selected
- **Binning**

•Offset of the active area from the bottom of the detector

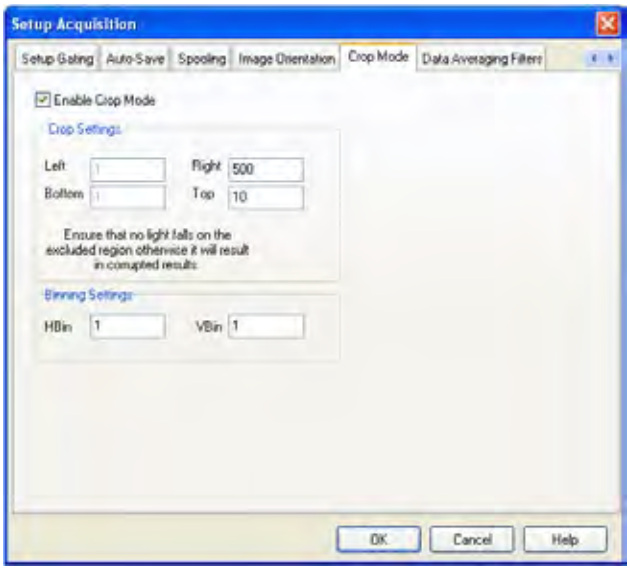
Note: Special offset flanges for Andor spectrographs are available so that active area of the sensor is positioned across the spectrograph optical axis, where best optical performance can be achieved.

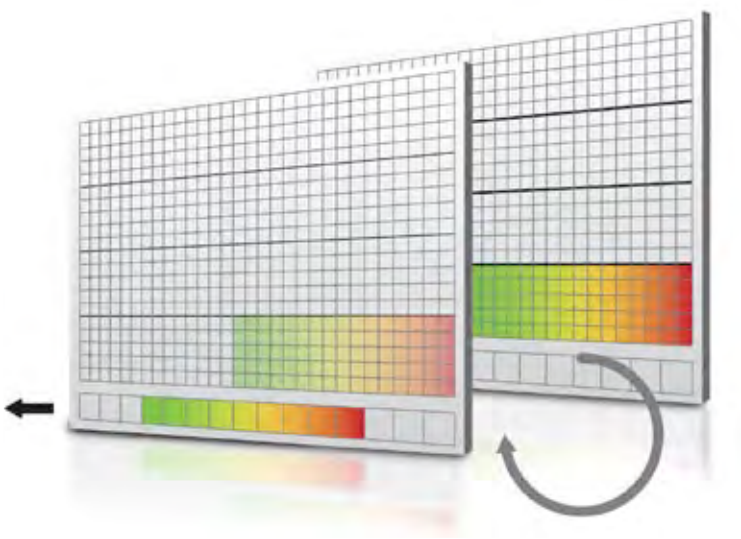
Note: When using fast kinetics mode, care should be taken to avoid (or greatly minimize) stray light falling on the bottom of the sensor, i.e. outside the active area of the sensor, in order to avoid useful, stored signal corruption.

Note: The use of Andor's Optomask for imaging applications should be considered to physically block unwanted light falling on to the storage part of the sensor.

5.3.1.5 - Cropped Sensor Mode

If an experiment demands the fastest image or spectrum acquisition rates, but cannot be constrained by the maximum storage size of the sensor (as is the case for 'Fast Kinetics Mode'), a specific 'Cropped Sensor Mode' can be set up through the main acquisition set up window, e.g.:





In this mode, the user defines a 'sub-array' size from within the full image sensor area, such that it encompasses the region of the image where change is rapidly occurring. The sensor subsequently 'imagines' that it is of this smaller defined array size, achieved through software executing special readout patterns, and reads out at a proportionally faster frame rate. The smaller the defined array size, the faster the frame rate achievable.

The cropped area must be positioned in the bottom-left of the sensor, thus the subject of study should be first positioned in this area rather than centrally located.

Note: Special offset flanges for Andor spectrographs are available so that crop area of the sensor is positioned across the spectrograph optical axis, where best optical performance can be achieved.

Note: When using crop mode, care should be taken to avoid (or greatly minimize) stray light falling on the top of the sensor, i.e. outside the active 'cropped' area of the sensor, in order to avoid useful signal corruption.

Note: The use of Andor's Optomask for imaging applications should be considered to physically block unwanted light falling on to the upper part of the sensor.

5.3.1.6 - Photon Counting

Photon Counting can only be successfully carried out with very weak signals, because as the name suggests, it involves counting only single photons per pixel. If more than one photon falls on a pixel during the exposure, an ICCD cannot distinguish the resulting signal spike from that of a single photon event, and thus the dynamic range of a single frame exposure is restricted to one photon.

Under such ultra-low light conditions, 'photon counting mode' imaging carries the key benefit that it is a means to **circumvent the Multiplicative Noise**, also known as '**Noise Factor**'. Multiplicative noise is a by-product of the Electron Multiplication process and affects both EMCCDs and ICCDs. This gives the new 'effective shot noise' that has been corrected for multiplicative noise.

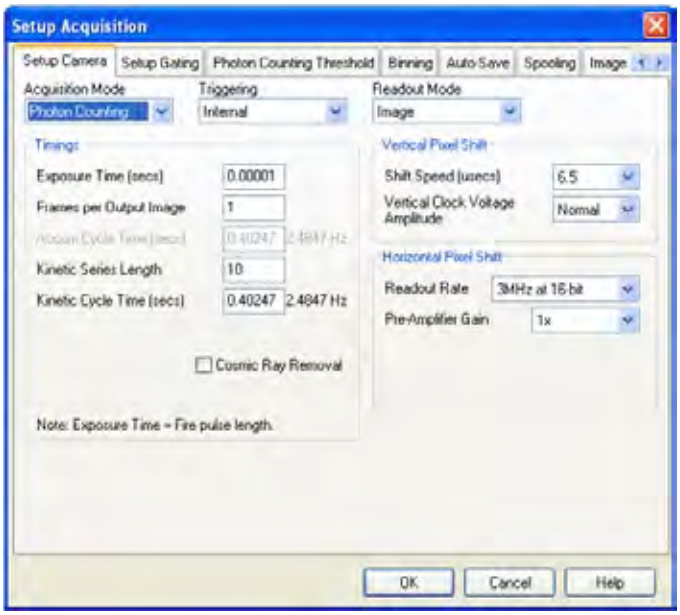
Photon Counting mode does not measure the exact intensity of a single photon spike, but instead registers its presence above a threshold value. It does this for a succession of exposures and combines the individual 'binary' images to create the final image. As such, this mode of operation is not affected by the multiplication noise (which otherwise describes the distribution of multiplication values around the mean multiplication factor chosen). The end result is that low light images acquired through this mode of acquisition are improved by a factor of ~x2-2.5 Signal-to-Noise, compared to a single integrated image with the same overall exposure time.

To successfully photon count with ICCDs, there has to be a significantly higher probability of seeing a 'photon spike' than seeing a darkcurrent/EBI 'noise spike'. The lower the contribution of this dark noise sources to a single exposure within the accumulated series, the lower the detection limit of photon counting and the cleaner the overall image will be.

5.3.1.6.1 - Photon Counting in Real-Time

As the ICCD is continually scanned, the signal builds up in computer memory and can be viewed live on the screen.

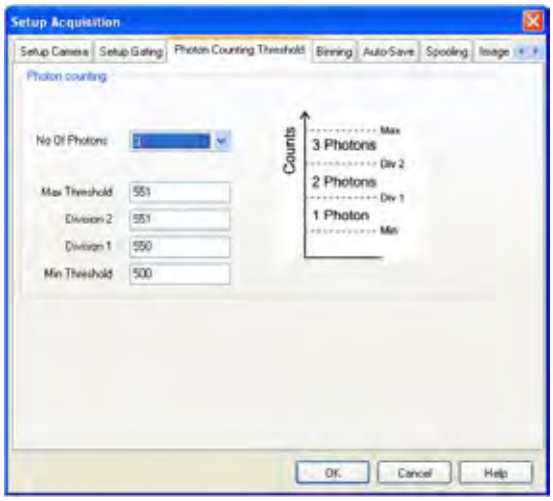
Photon Counting can be selected and configured from the **Acquisition Mode** drop-down menu of the dialog box, e.g.:



Parameters to be set are:

- **Exposure Time** per acquisition
- Number of **Acquisitions per Output Image or spectrum**
- **Kinetic Series Length** required.

The **Photon Counting Threshold** tab provides the following interface:



Min.Threshold and **Max. Threshold** values can be set to define the signal intensity range considered for the detection of the single photons events. The new iStar photon counting mode allows selection of several 'counting levels' to especially differentiate several photons from a single pixel or column - the latter is especially useful when working in FVB mode. Each level is defined by a signal intensity in counts.

The **histogram** option selectable from the quick access button on the main window allows easy visualization of signal brackets population.

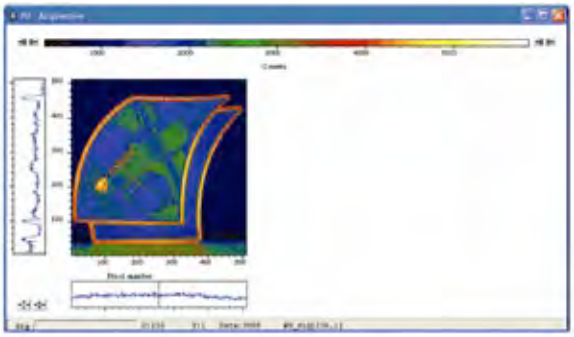
5.3.2 - Readout Modes

The signal captured by a 2D CCD sensor can be read in several different ways, adapted to specific experimental configurations. The main options available are:

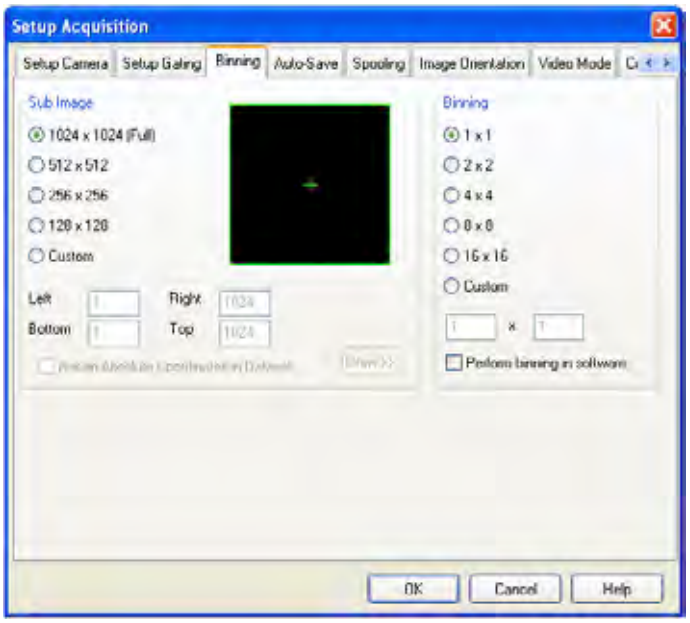
- **Image** (including sub-array and binning)
- **Multi-Track**
- **Full Vertical Binning (FVB)**

5.3.2.1 - Image Mode

The default image display mode is referred to as 'full resolution image', whereby signal information (in counts) of each individual pixel of the CCD is reported and accessible, e.g.:



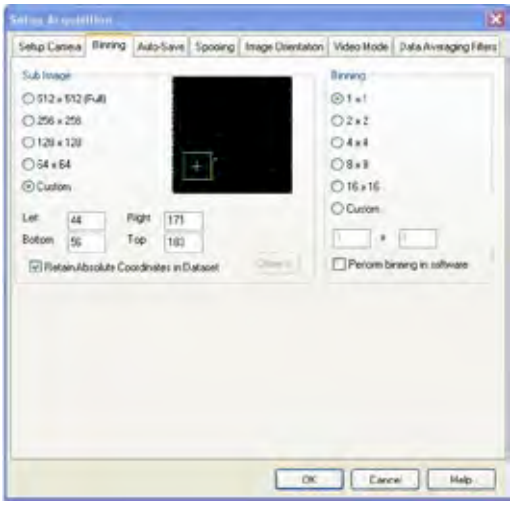
By selecting the **Binning** tab in the setup aquisition interface the following options appear:



This interface allows the user to tailor the image display through sub-arrays/sub-images, or binning.

5.3.2.1.1 - Sub Image

For the purpose of initial focusing and alignment of the camera, or to increase the frame or spectral rate, user may select a sub-image of the CCD chip. When the camera is running in sub-image mode, only data from the selected pixels will be read out, and data from the remaining pixels will be discarded. To read out data from a selected area (or sub-image) of the CCD, the radio buttons should be toggled to select the required resolution as shown below:



Note: The standard choices of sub-image configuration will vary with the CCD matrix used.

A custom sub-image can also be used to set a specific size and location of the desired aquisition area on the CCD chip. To user-define a sub-image, the custom radio button should be selected so that the co-ordinate fields appear.

Draw

In addition to the previous methods of defining a sub-image on the sensor, a **Draw** option can be used to graphically select the size and location of the sub-image. A full resolution image must first be acquired to provide the template on which the sub-image will be drawn. The button displays the Draw tool on the full resolution image.

Note: 'Restore Absolute Co-ordinates in Data Set' allows user to retain actual pixel X-Y co-ordinates on the CCD

5.3.2.1.2 - Image orientation

In image mode, the data can also be orientated in a specific way as they are acquired. The orientation of the image data is accessible from the **Image Orientation** tab on the **Setup Acquisition** dialogue box e.g.:

5.3.2.2 - Multi-track Mode

Multi-track mode allows creation of one or more individual aquisition tracks that can be defined (in rows) by the height of each track, and the offset on the CCD-chip, which in effect 'raises' or 'lowers' the pattern of tracks from which the charges will be read out.

In this way, the position of the tracks can be adjusted to match a light pattern produced on the CCD-chip by a fiber-optics bundle for example. To define multiple tracks on the CCD-chip can be defined under the **Multi-track** section from the **Readout Mode** drop-down menu in the **Setup Acquisition** dialog box:

By clicking the

button, the following **Setup Multi-track** dialog box opens, e.g.:

There are two modes of operation, i.e. **Standard** or **Custom**.

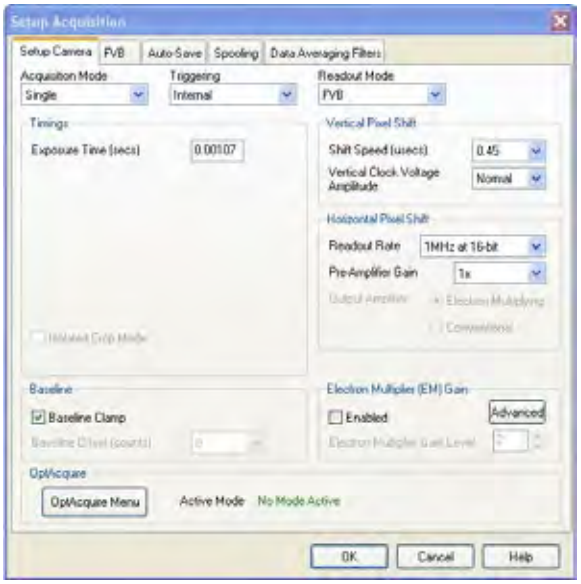
- In **Standard** mode, the user defines the **Number of tracks**, the **Height** & **Offset**. The software automatically calculates the position of the tracks by distributing them evenly across the sensor.
- In **Custom** mode, the user has the ability to define the tracks as required, e.g.:

The user can also save the position of the individual tracks to a file that can be reloaded later. The **Load** and **Save** buttons are used to achieve this. The user can also utilize the **Insert** and **Delete** buttons to define or remove tracks. If the Advanced button is clicked, the **Advanced Multi-track** options dialog box appears:

This allows the user to define the horizontal binning and position of all the tracks. The **Transfer** button can be used to quickly load the automatically calculated tracks from the standard mode setup into custom mode.

5.3.2.3 - Full Vertical Binning (FVB)

FVB allows the user to operate the CCD-chip as a linear image sensor (a photodiode array), typically for spectroscopy applications. The charges from each column of pixels (each column being the chip height) are combined, or binned, on the chip to give one single signal value per column. **FVB** mode is selected in the **Setup Acquisition** dialog box as shown below:



For some spectrographs, it may be necessary to change the direction in which the data is displayed on screen. This is accessible in the setup acquisition dialogue, in the FVB tab as shown below:

In some instances spectral rate can be more important than spatial/spectral resolution. For such applications, horizontal binning can be applied by setting the desired binning format in the **Horizontal Binning** section of the acquisition setup interface (see section 5.3.3.1) to a value greater than one.

5.3.3 - Binning

Binning is a process that allows charge from two or more **pixels** to be combined on the **CCD**-chip prior to readout. Summing charges on the CCD and doing a single readout gives better noise performance than reading out several pixels and then summing them in computer memory. This is because each act of reading out charges from the CCD contributes to noise.

Combining both the vertical and horizontal binning methods produces '**superpixels**'. These consist of two or more individual pixels that are binned and read out as one large pixel. Thus the whole CCD, or a selected sub-area becomes a matrix of superpixels.

On the one hand superpixels result in a loss of spatial resolution when compared to single pixel readout, but on the other hand they offer the advantage of summing data on-chip prior to readout, thereby producing a better signal-to-noise ratio and a higher frame rate.

5.3.3.1 - Vertical Binning

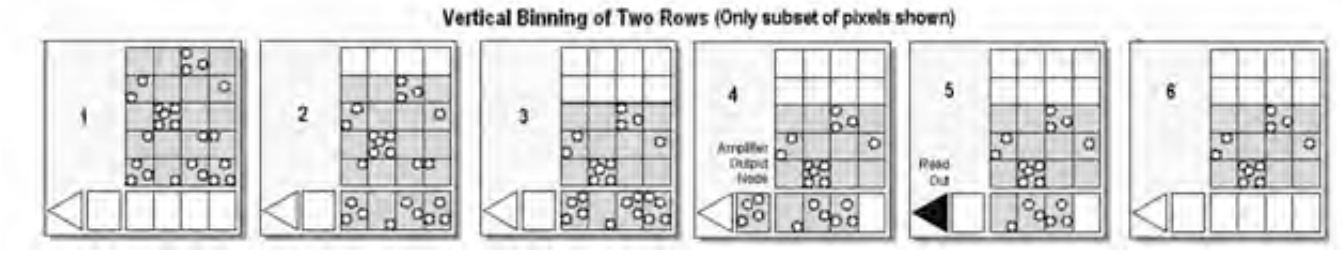
Charges from two or more rows of the CCD-chip are moved down into the shift register before the charges are read out. The number of rows shifted depends on the binning pattern selected. Thus, for each column of the CCD-chip, charges from two or more vertical elements are **summed** into the corresponding element of the shift register. The charges from each of the pixels in the shift register are then clocked horizontally to the output amplifier and read out.

1. **Single-Track**: Charges are vertically binned and read out from a number of user-selected adjacent rows of pixels on the CCD-sensor. The rows form a single track across the full width of the CCD-sensor.

2. **Multi-Track**: This mode differs from single-track in that user now defines two or more tracks (groups of rows) on the CCD from which to read out charges. In processing terms, each track is treated as in single track.

3. **Full Vertical Binning (FVB)**: Charges from each complete column of pixels on the CCD are moved down and summed into the shift register, and the charge is then shifted horizontally one pixel at a time from the shift register into the output node - in effect a value is read out for each complete column of the CCD-sensor. This mode is typically used for spectroscopy (please refer to section 5.3.3.3).

The example below illustrates readout of data from adjacent tracks, each track comprising two binned rows of the sensor.



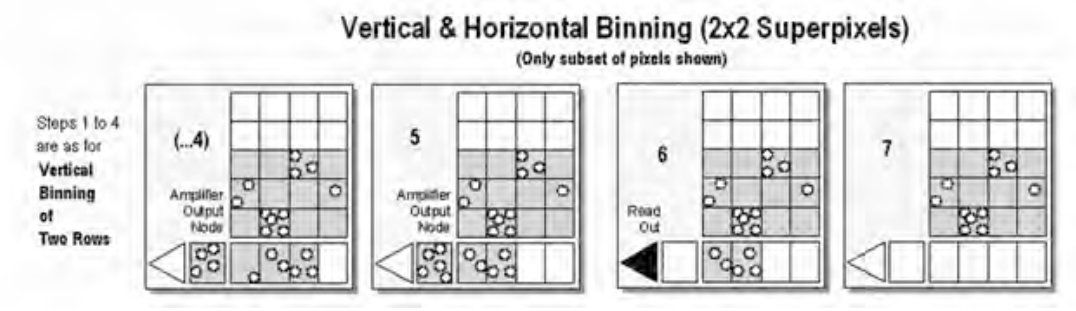
1	Exposure to light causes a pattern of charge (an electronic image) to build up on the frame (or 'image area') of the CCD-sensor.
2	Charge in the frame is shifted vertically by one row, so that the bottom row of charge moves down into the shift register.
3	Charge in the frame is shifted vertically by a further row, so that the next row of charge moves down into the shift register, which now contains charges from two rows - i.e. the charges are vertically binned
4	Charges in the shift register are moved horizontally by one pixel, so that charges on the endmost pixel of the shift register are moved into the output node of the amplifier.
5	The charges in the output node of the amplifier are passed to the analog-to-digital converter and are read out (digitized).
6	Steps 4 and 5 are repeated until the shift register is empty. The process is repeated from Step 2 until the whole frame is read out.

5.3.3.2 - Horizontal Binning

In this configuration, charges from two or more pixels in the serial register are transferred into the output amplifier and read out as one combined data value. Thus the charges from two or more of the horizontal elements are effectively summed into the output amplifier before being readout.

In the example below (where each superpixel is of dimensions 2 x 2 pixels) charges from two rows is first binned vertically into the shift register; then charges from two pixels of the shift register are binned horizontally into the output node of the amplifier. The effect of the combined binning processes is a summed charges equating to a 2 x 2 **'superpixel'**.

Since this example initially involves binning charge from two rows, the process begins in the same way as the previous example (see **Steps 1 - 4** of **Vertical Binning** section).



(...4)	Charges from two rows have already been vertically binned into the shift register. Charges in the shift register are now moved horizontally by one pixel, so that charges on the endmost pixel of the shift register are moved into the output node of the amplifier.
5	Charges in the shift register are again moved horizontally, so that the output node of the amplifier now contains charges from two pixels of the shift register - i.e. the charges have been horizontally binned.
6	The charges in the output node of the amplifier are passed to the analog-to-digital converter to be read out.
7	Steps 4 to 6 are repeated until the shift register is empty. The process is repeated from Step 2 (in Vertical Binning section) until the whole frame is read out.

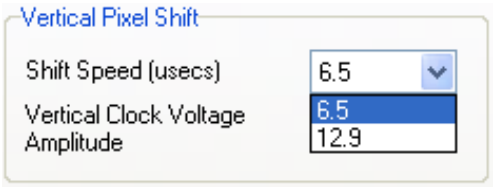
5.3.4 - CCD Clocking Speed

5.3.4.1 - Vertical Pixel Shift

Shift speed

Shift Speed (µsecs) specifies the time taken clock (shift) charges from one row on the CCD sensor to the next. Speeds which appear un-bracketed in the drop-down list are guaranteed to meet all the system specifications. In some instances, using a slightly slower vertical shift speed may result in a slight increase in the single well capacity for imaging applications. However it may also reduce the maximum frame/spectral rates achievable.

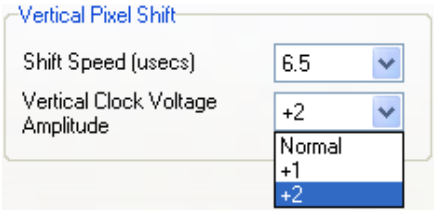
Bracketed vertical shift speed values are also available (CCD-model dependant) to achieve even faster acquisition rates. However, with this setting the pixel well depth and charge transfer efficiency may be impacted.



Vertical Clock Amplitude Voltage

The vertical clock voltage amplitude can be used to increase the amplitude of the clock pulses used to perform row shifts on the CCD. The normal setting is the default amplitude which has been set at the factory during the optimization and testing of the camera. The other settings (if available) specify the voltage increase to be applied to this clock amplitude. In some imaging applications, increasing this voltage can provide a slightly higher single pixel well depth and improve charge transfer efficiency, at the expense of slightly higher CIC.

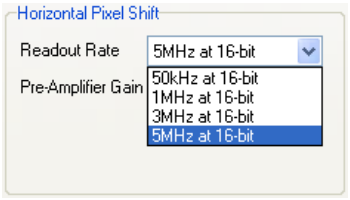
Application of higher voltage may be required in combination with the fastest of the bracketed vertical pixel shift speeds in order to overcome image distortion effects that result from reduced charge transfer efficiency. Best practice is to select the fastest vertical shift speed, then step the vertical clock voltage 1 unit at a time until distortive effects disappear from the image.



5.3.4.2 - Horizontal Pixel Shift

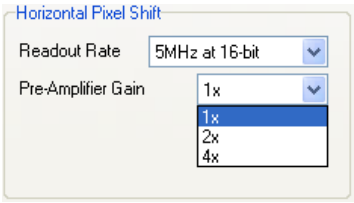
Readout Rate

Horizontal pixel shift readout rate defines the rate at which pixels are read (or digitized) from the shift register. The faster the horizontal readout rate the higher the frame rate that can be achieved. Slower readout rates will generate less noise in the data as it is read out. The available rates are system dependant, and can be selected from a drop-down list on the **Setup Acquisition** dialog box, of which an example is shown below:



Pre-Amplifier Gain

Pre-amplifier gain determines the amount of gain applied to the video signal emerging from the CCD and allows the user to control the sensitivity of the camera system. Depending on the system there are up to three options available. They are again selected from a drop-down menu on the **Setup Acquisition** dialogue box:



These normalized gain settings will correspond to system sensitivities specified on the performance sheets (in terms of electrons per A/D count) which accompany the system.

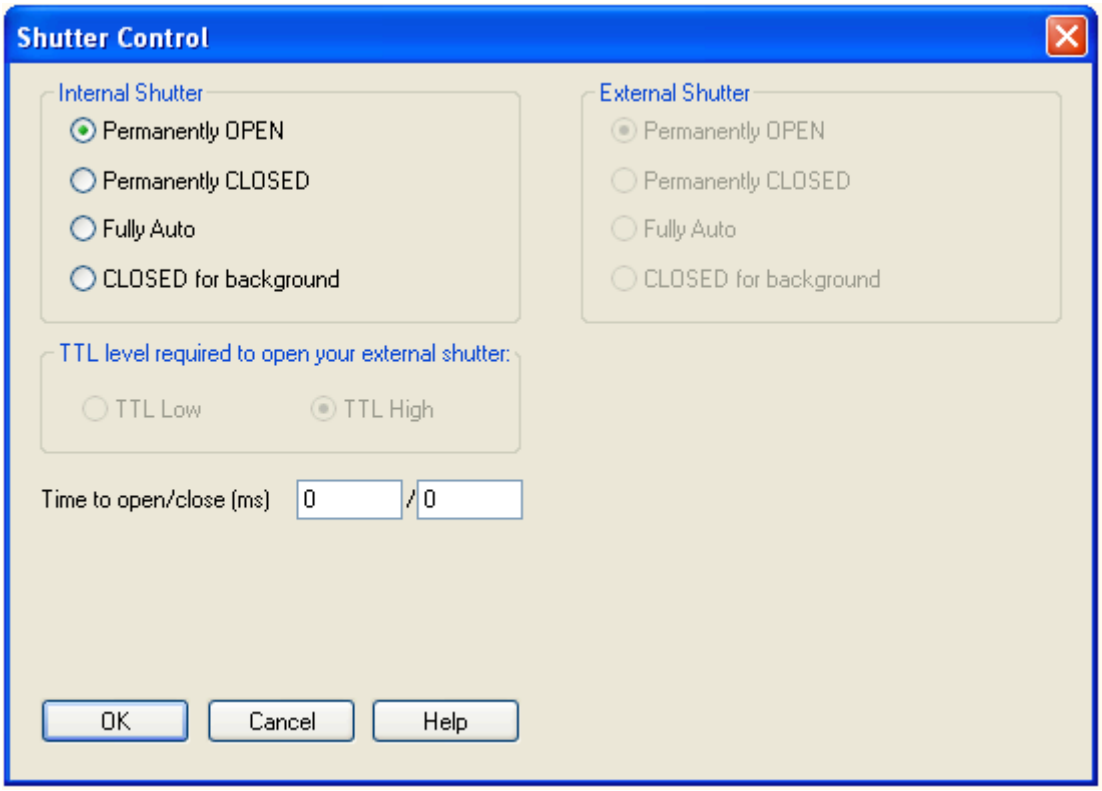
Selecting higher pre-amplifier gain values (i.e. x2 or x4) will increase the sensitivity of the camera (i.e. fewer electrons will be required to produce one A/D count) and provide the lowest readout noise performance. However this may result in the A/D converter saturating before the single pixel / register capacity of the CCD sensor is reached.

5.3.5 - Shutter

With an ICCD, a mechanical shutter can be used for background acquisition in complement of the image intensifier optical shuttering (photocathode gating). Indeed the photocathode may exhibit some light leakage during exposure to bright light source even when 'Off'. But it is essentially used to protect the photocathode from unneccessary photo-bleaching between acquisitions or during storage of the equipment.

A shutter can be used to take a reference or background if FVB is selected. For either multi-track or image mode, the shutter may be required to avoid unnecessary signals/light falling on the photocathode or CCD during the readout process.

When the **Shutter Control** option is selected from the **Hardware** drop-down-menu, or the button is clicked, the shutter control dialog box opens, e.g.:



Note: Certain settings (e.g. Permanently OPEN & Permanently CLOSED) take effect as soon as the Shutter Control dialog box is closed. Other settings will be applied whenever data acquisition is started.

- In **Permanently OPEN** mode, the shutter will be open before, during and after any data acquisition. However if the camera is to be left unattended for long periods, it is recommended that the shutter is closed.
- **Permanently CLOSED** mode can be useful for taking a series of acquisitions in darkness (background) and do not require the shutter to open between acquisitions. The shutter remains closed before, during and after any data acquisition.
- **Fully Auto** is the simplest shutter mode, as it leaves all shuttering decisions to the system. When a Take Signal operation is performed, the shutter opens for the duration of the CCD exposure time.
- If **CLOSED for background** mode is selected, any shutter driven from the shutter output of the camera will be closed during background acquisition only.
- The **TTL** (Transistor-Transistor Logic) buttons, TTL Low & TTL High, allow user to instruct the system as to how it should control the opening and closing of the shutter i.e. open or closed status during high or low TTL states.

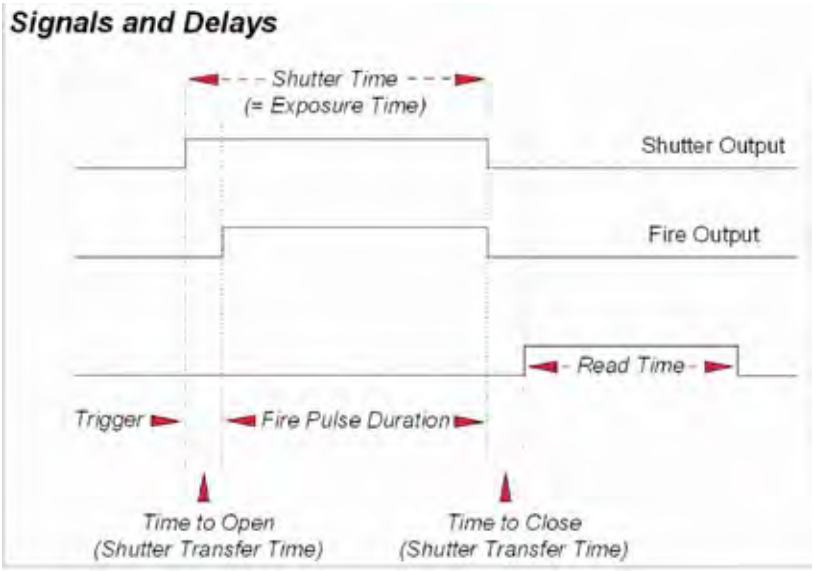
Note: The shutter pulse is not capable of driving a shutter. It is only a 5V pulse designed to trigger TTL & CMOS compatible shutter drivers. The shutter pulse from the camera ca be directly connected to Andor Shamrock spectrographs in order to control the internal shutter of these instruments, or to an Andor ACC-SD-VDM1000 external shutter driver for stand alone shutter operation.

5.3.5.1 - Shutter Transfer Time

Shutters take a finite time to open or close and this is sometimes called the **S**hutter **T**ransfer **T**ime **(STT**). This is typically in the order of a few tens of milliseconds, and will vary from one shutter type to the other. The STT should give enough time for the shutter to open before acquisition starts, and enough time to close after acquisition finishes and before readout commences.

Note: Mechanical shutters are limited to repetition rates of a few Hz for correct 'opening' and 'closing' operation. This frequency will vary from one shutter type to the other. If acquisition rate of the CCD exceeds the maximum recommended shutter rate, then this will cause partial operation of the shutter blades and potential damage to the device. At that stage, shutter should either be left fully opened (and image intensifier photocathode becomes the sole signal shuttering interface in the system), or CCD acquisition rate should be decreased.

By default, the value entered in the exposure time text box on the **Setup Acquisition** dialog box determines the length of time the shutter will be in the open state. However, to accommodate the transfer time, the rising edge of the shutter output is sent before the Fire output signal by an amount equal to the preset STT. The system automatically adds the transfer time to the end of the acquisition sequence, introducing an appropriate delay between the start of the shutter closed state and the commencement of the data being read out as shown in the following example diagram:



Important note: If no shutter is connected, the time to open or close should be set to 0. Setting the Time to open or close to any other value will insert extra delays into cycle time calculations.

5.3.6 - Acquistion and Data Types Selection

Some acquisitions, such as quantitative measurements or absorption / transmission / reflection require a degree of data processing which can be executed and displayed seamlessly in Solis.

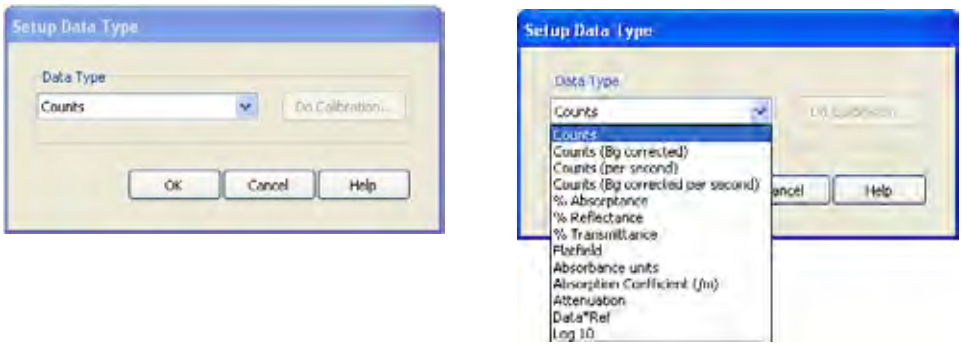
5.3.6.1 - Definitions of Data Types

Data processing and display involves the following bassline information:

- **Signal:** Uncorrected raw data acquired via **Take Signal**. 'Signal', as used in the definitions of the calculations, refers to 'raw' data from the detector and should not be confused with the possibly 'processed' data to be found under the **Sig** tab of the **Data** window.
- **Background:** Data in uncorrected counts, acquired in darkness
- **Reference:** Background corrected data. Reference data is normally acquired from the light source, without the light having been reflected from or having passed though the material being studied

5.3.6.2 - Data Display and Processing Modes

The data processing and display formats can be selected from the **Acquisition** drop down menu under **Setup Data Type,** e.g.:

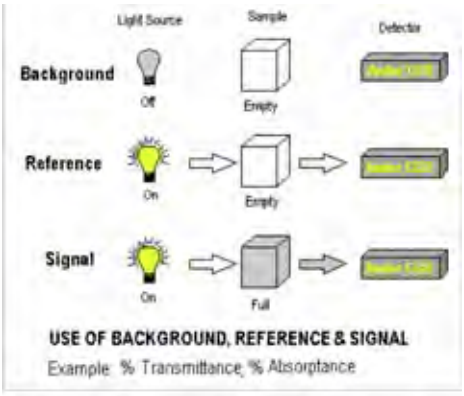


The descriptions of the different available data display and processing types are shown in **Table 8**.

OPTION	FUNCTION
Counts	Counts represent raw, digitized data (i.e. no calculations have been performed on the data) from the EMCCD detector's analog to digital (A/D) converter. Please refer to the detailed performance sheet accompanying your particular EMCCD detector for the number of electrons that correspond to 1 count.
Counts (Bg corrected)	Counts (Background Corrected) is digitized Data from the EMCCD detector's analog to digital (A/D) converter, where Background (or dark signal) has been removed. Counts (Bg. Corrected) = Signal - Background
Counts (per second)	Counts ÷ Exposure Time.
Count (Bg corrected per second)	Counts (Bg corrected) ÷ Exposure Time.
%Absorptance	Represents the light absorbed by an object. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then: % Absorptance = 100 x (1 - (Signal - Background) / Reference)
%Reflectance	Represents the light reflected by an object. If Reference is the background corrected incident intensity, and Signal - Background the reflected intensity (i.e. the intensity of light which has been reflected from the material being examined), then: % Reflectance = 100 x (Signal - Background) / Reference
%Transmittance	Represents the light transmitted by an object. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has been transmitted through the material being examined), then: % Transmittance = 100 x (Signal - Background) / Reference
Flatfield	Flatfield is used to remove any pixel-to-pixel variations that are inherent in the ICCD sensor. If Reference is the background corrected incident intensity, the Signal is divided by the Reference so: Flatfield = M x Signal / Reference Where M is the Mean of Reference.
Absorbance units	A measure of light absorbed by an object (i.e. they represent the object's Optical Density - OD). If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then Transmission = (Signal - Background) / Reference. Absorbance Units are defined as Log10 (1 / Transmission). Therefore: Absorbance Units = Log10 (Reference / (Signal - Background)).
Absorption Coefficient (/m)	Indicates the internal absorptance of a material per unit distance (m). It is calculated as -loge t, where t is the unit transmission of the material and loge is the natural logarithm. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then: Transmission = (Signal - Background) / Reference and: Absorption Coefficient = -loge ((Signal - Background) / Reference)
Attenuation	A measurement, in decibels, of light absorbed due to transmission through a material - decibels are often used to indicate light loss in fiber optic cables, for instance. If Reference is the background corrected incident intensity, and Signal - Background the transmitted intensity (i.e. the intensity of light which has passed through the material being examined), then: Attenuation = 10 x log10 ((Signal - Background) / Reference)
Data*Ref	Allows you to 'custom modify' the background corrected signal: Data x Ref = (Signal - Background) x Reference Store Value See the Andor Basic Programming Manual for similar operations.
Log 10	Calculates the logarithm to the base 10 of the background corrected signal counts. Log Base 10 = log10 (Signal - Background)
Radiometry (Optional extra)	Allows you to calculate values for radiance or irradiance. The system requires that you supply calibration details. This option must be ordered separately.º

Table 8: Data type and display available in Solis

The illustration below shows a typical use of Background, Reference and Signal for computations such as %Absorptance or %Transmittance:



For example, the % Absorption will be computed as:

100 x (1 - (Signal - Background) / Reference)

The default data type (used when capturing data and having not explicitly made a selection from the **Data Type** dialog box) is **counts**.

If any data type other than counts or counts (Bg Corrected) are selected, user will have to perform **Take Background** and **Take Reference** (in that order) before performing **Take Signal**.

5.3.7 - Autoscale Acquisition

Prior to the **Take Signal** function being activated, autoscale acquisition can be selected from the **Acquisition** drop-down menu as shown below (or F6 on the keyboard):

- With autoscale acquisition deselected, the display will remain the same size regardless of brightness settings, etc. When not selected, the button appears.
- With autoscale acquisition selected, the system will configure the acquisition window (if necessary adjusting its scales in real time) so that all data values are displayed as they are acquired. The button appears when selected on. The data are displayed in accordance with the selection made on the **Rescale Data Mode** on the **Display** Menu:

Different scaling modes are available as follows:

- Minimum & maximum **(Min..Max)**
- Zero & maximum **(0..Max)**
- Zero & 16383 **(0..16383)**
- Minimum & 16383 **(Min..16383)**
- Zero & 65535 **(0..65535)**
- Minimum & 65535 **(Min..65535)**
- Custom setting as required - user selectable min and max display range

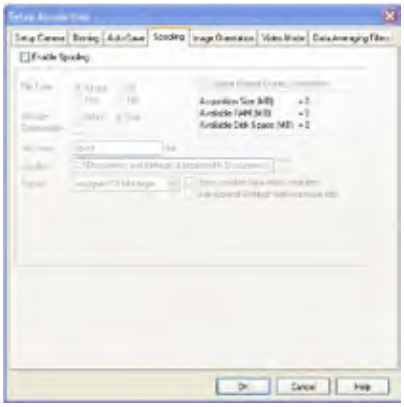
Note: The histogram icon can be used to adjust conveniently and in real time signal display scaling.

5.3.8 - Data File Handling

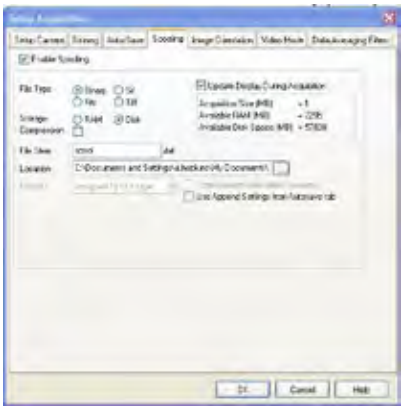
5.3.8.1 - Spooling

The Andor Solis software has an extensive range of options that allows user to spool acquisition data direct to the hard disk of your PC. This is particularly useful when acquiring a series of many images. The amount of data generated by a kinetic series of, for example 1,000 acquisitions, is huge and more than most PC RAM can handle.

To select click on the **Spooling ta**b and the **Spooling** dialog box appears e.g.:



With the spooling function enabled, data is written directly to the hard disk of you PC, as it is being acquired. The **Enable Spooling** function should be selected as shown below, and user should enter the relevant stem name and location root e.g.:



Note: Spooling large amounts of data straight to hard disk for later retrieval requires a hard disk of sufficient read-write speed. Andor recommends only very high-speed hard disk drives be used for this type of operation and these need to be dedicated for spooling.

5.3.8.2 - Virtual Memory

In addition to the spooling function, it can also be useful to have the Virtual Memory (VM) function enabled. This will speed up the retrieval of large data sets and allow larger data sets to be acquired. This works by buffering data in the hard drive of the PC. The **Virtual Memory**… option is selected from the **File** menu, e.g.:

This will open the **Virtual Memory** dialog box,e.g.:

User should select the **Enable** box and the required **Threshold** level. The data is normally saved to the default directory shown in the **Location** field. Alternatively, user can click on the ... button and choose a different area to save the data.

Note: It is recommended to have the option activated for images > 50 MB.

5.3.8.3 - Auto-Save

Auto-Save allows user to set parameters and controls for the auto saving of acquisition files thus removing the worry of lost data and files. Selection of this mode is accessible under the **Auto-Save** tab on the **Setup Acquisition** dialog box. The **Auto-Save** dialog box appears, e.g.:

If selected, acquisitions will be saved automatically after each individual one is completed. Each subsequent auto-saved file will over-write the previously auto-saved one.

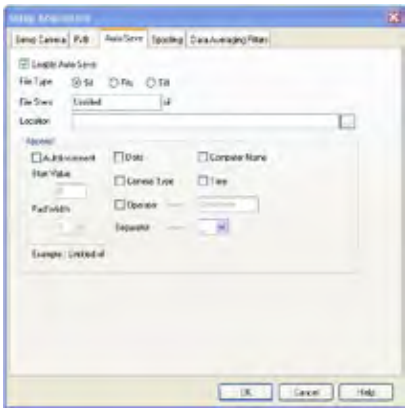
In the Auto-Save dialog box, a **Stem Name** may be entered. This is the main root of the name that the acquisition is to be saved as.

The Stem Name can be appended with a number of details, e.g.:

- Operator name (supplied by user)
- Computer name
- Camera type
- Date
- Time

An auto-increment On/Off tick box allows a number to also be entered to the main stem name. This number is automatically incremented each time a file is saved.

Any combination of these may be selected by activating the relevant tick box, e.g.:



Note: This function will only auto-save single scan, kinetic series or accumulated images.

5.4 - IMAGE INTENSIFIER SETTINGS

This section details the different image intensifier modes of operation relative to 'gating' and signal amplification.

5.4.1 - Gate Modes

In the Setup Acquisition interface, under Setup Gating tab, a drop-down menu allows the user to select the gate mode used for data acquisition. Valid options are:

GATE MODE	DESCRIPTION
Fire and Gate	Photocathode is switched on only when both the Fire & Direct Gate input are high.
Fire only	Photocathode is switched on only when the Fire pulse is high.
Gate only	Photocathode is switched on only when the Direct Gate input is high.
CW On	The photocathode is continuously in the ON state
CW Off	The photocathode is continuously in the OFF state.
DDG	The photocathode is switched on only when the Gate pulse from the DDG is high.

Note: For direct gate input, the maximum safe levels are -0.5 to +5.75 V. The input impedance is 50 Ω termination to ground. The minimum high logic level is 1.7 V and maximum low logic level is 0.8 V.

5.4.2 - Using Gate Monitor

The gate monitor connection, on the side of the main block of the New iStar, enables the user to monitor the temporal position of the photocathode switching On (negative spike) and Off (positive spike). A cable is supplied with the New iStar, which has a BNC connector on one end for attaching to an oscilloscope.

When Intelligate (see section 5.4.5) is selected an additional gate monitor spike precedes the spike from the photocathode. This spike corresponds to the MCP switching on.

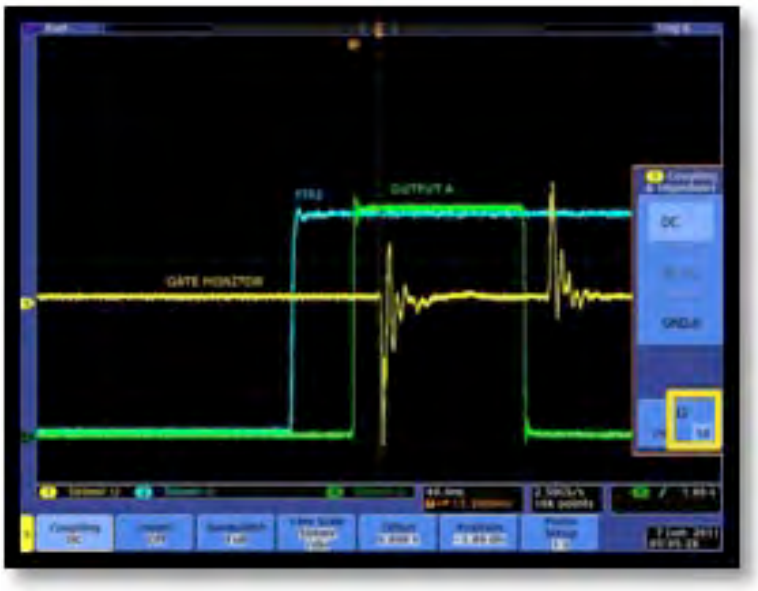
User should set the oscilloscope to trigger on the steepest part of Output A, typically to ½ of the peak amplitude. The Fire pulse may also be used but its jitter performance with respect to the gate pulse will not be as good.

The plots on the next page show the preferred oscilloscope settings for working with short and long gate widths.

Fire Pulse (Blue)

Gate Monitor (Yellow)

Output A (Green)



Short Gate Widths (<1 us)

For example: 100 ns gate width:

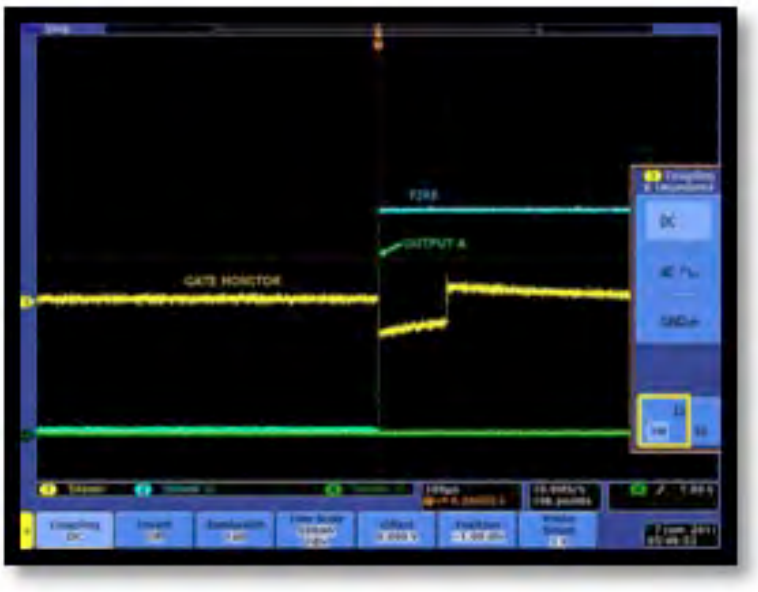
Set input impedance on oscilloscope to 50 Ω.

Set Voltage amplitude to 500 mV

Fire Pulse (Blue)

Gate Monitor (Yellow)

Output A (Green)



Long Gate Widths (>1 us)

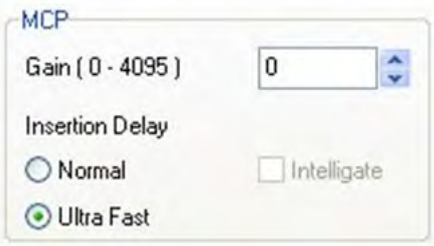
For example: 100 us gate width:

Set input impedance on oscilloscope to **1 MΩ.**

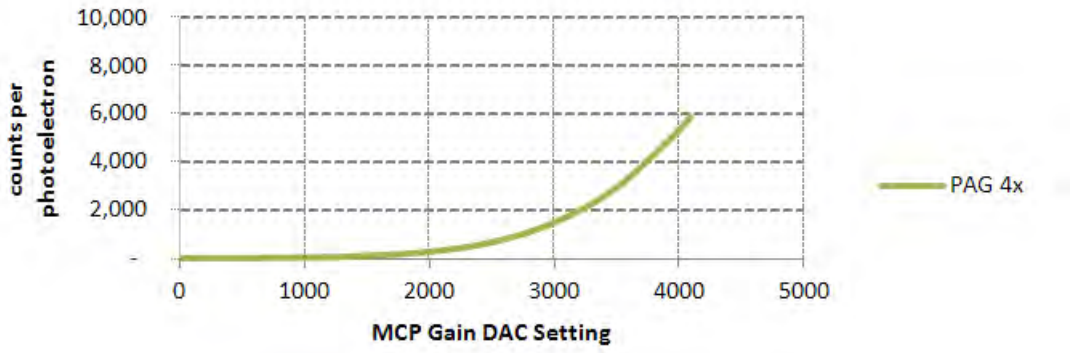
Set Voltage amplitude to 500 mV

5.4.3 - MCP Gain

The gain of the Micro-Channel Plate (MCP) in the image intensifier can be varied through software from a setting of 0 to 4,095. By increasing the gain, the voltage across the MCP is increased and hence the signal reaching the CCD sensor is amplified. The value can be entered in the **MCP Gain** text box of the **Setup Gating** tab of the **Setup Acquisition** dialog box. It can also be selected on the **Run time** control dialog box, e.g.:



The graph below shows typically how the signal level on the CCD sensor varies with increasing gain setting.



Note: MCP gain versus DAC settings is reported for each system on the associated performance sheet.

5.4.4 - Insertion Delay

Insertion delay refers to the propagation delay of a trigger source (External Trigger, Internal Trigger (Fire pulse) or Direct Gate) to travel through the electronics and open the image intensifier. A radio button allows the user to select between 'Normal' and 'Ultra Fast' options. Switching from 'Ultra Fast' to 'Normal' adds 100 ns delay to the gate pulse. This allows the MCP voltage to rise and settle when using Intelligate before opening the photocathode. Intelligate is not available when using 'Ultra Fast' insertion delay.

External Trigger to intensifier opening using DDG

Ultra Fast ≈ 35 ns

Normal ≈ 135 ns

Fire pulse to intensifier opening using DDG

Ultra Fast ≈ 50 ns

Normal ≈ 150 ns

Direct Gate to intensifier opening

Ultra Fast ≈ 20 ns

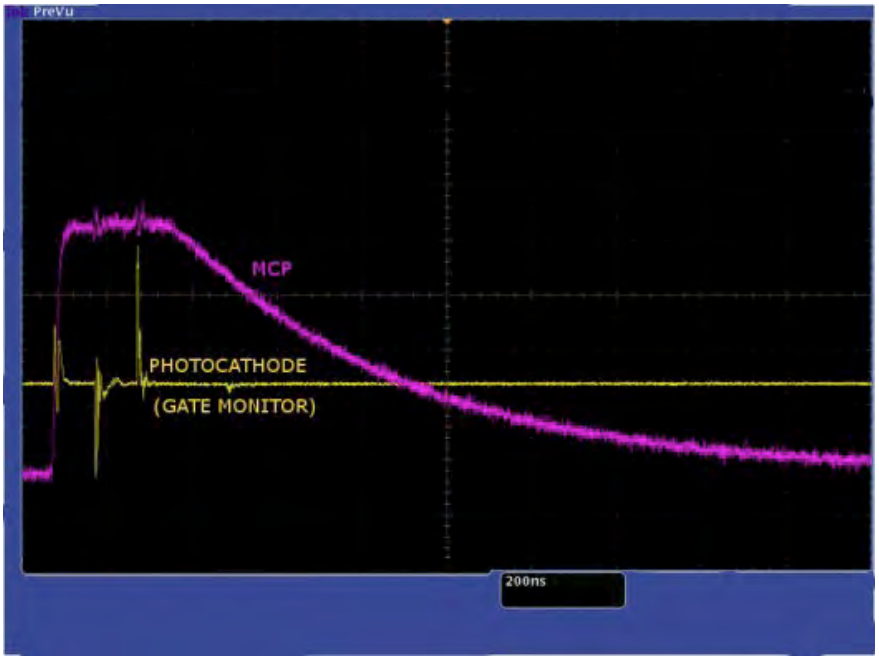
Normal ≈ 120 ns

5.4.5 - Intelligate

With traditional Image Intensifier gating the photocathode of the tube is switched on and off. But even when the photocathode is switched off, some photons can still pass through it and reach the Microchannel Plate (MCP). UV photons can be energetic enough to be converted into photoelectrons that are amplified by the MCP in the normal way, and are then detected by the CCD sensor. The ability of the Image Intensifier to reject photons when it is switched off becomes worse in the UV, so the On/Off ratio of the tube is compromised. The solution to this, as utilized by Andor's Intelligate™ function, is to gate the MCP as well as the photocathode.

A checkbox is accessible under the **Gating** tab of the Setup Acquisition menu allows the user to apply the Intelligate function.

The gating electronics will output a fast rising edge that is sent to the MCP. After a 100 ns delay, which allows the MCP voltage to rise and settle, the photocathode will open. The MCP will remain at the gain value (as set by the user in the software) for the duration of the gate width, and then the MCP will decay rapidly. This method of gating eliminates the need for a pre-pulse or anticipator circuit and results in photoelectron rejection of better than 10^7:1, below 200 nm.



MCP Gating in practice

5.4.6 - Integrate On Chip (IOC)

IOC is a function that enables the image intensifier to be opened and closed a number of times while the CCD sensor makes a single acquisition. Light signal passes through the intensifier while it is open (or switched on) and reaches the CCD sensor. The CCD sensor accepts the light continuously for the entire duration of the acquisition while the intensifier is opening and closing. Charges are built up on the sensor or 'integrated' until the acquisition is complete. Then all the charges that have been built up are read out in the normal way.

IOC greatly improves the signal-to-noise ratio achievable, since the signal is being integrated on the sensor itself while being read out once. Hence noise will only be generated from a single readout. The signal-to-noise ratio achieved while operating the New iStar's IOC function is better than that obtained while operating the system in accumulate acquisition Mode. This is because during accumulate mode, the CCD is read out a number of times and accumulated in computer memory. So the signal-to-noise ratio in this case will include noise generated from each read out that occurs.

This mode also allows to mimimize the CCD dark current contribution by filling up the CCD exposure time with multiple useful signal contributions, further enhancing the overall signal-to-noise performance.

A checkbox, accessible on the **Gating** tab of the **Setup Acquisition** interface, allows the user to apply the Integrate On Chip function and is only available in DDG gate mode.

IOC allows several gate pulses, as well as outputs A/B/C synchronization signals, to be generated within the CCD exposure. When outputs A, B, or C are enabled, the first set of pulses is determined by the delay and width of these outputs as set by the user. The delay applies from the rising edge of the Fire pulse for internal trigger or rising/falling edge (user selected) for external trigger. This delay is in addition to the inherent insertion delay.

Once the first set of pulses is finished, subsequent sets are spaced out by the period/frequency pre-set in the IOC section. Since subsequent sets cannot start before the first set is finished, the software automatically adjusts the period/frequency according to the time from the start of the first pulse to the end of the last pulse. The start of the first pulse could be the delay value in gater or output A/B/C, and the end of the last pulse could be the delay plus width of gater or output A/B/C.

Please refer to the following page for detailed setting of these modes under different trigger conditions.

INTERNAL TRIGGER			
	IOC OPTIONS	**DESCRIPTION**	
Pulses per Exposure	Fit to CCD exposure:	Software calculates the maximum number of pulses that can fit into the exposure. The Fire pulse generates the first pulse determined by the delay and width fields, subsequent pulses are generated internally in the DDG by a user defined period/ frequency.	
	Burst:	Same as “Fit to CCD exposure” but the user can chose the number of gate pulses per exposure.	

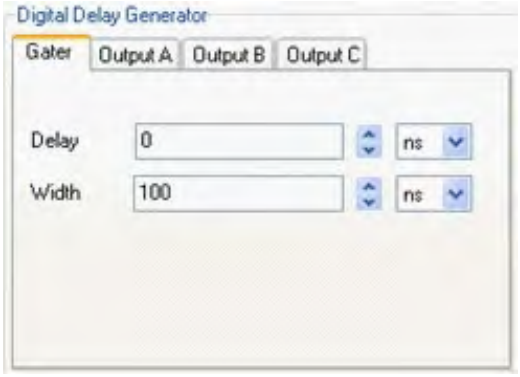
Note: A default minimum of 20 ns delay applies when Integrate on Chip is selected and when the DDG generates the pulse train internally by a user-defined frequency or period. This is a characteristic of the DDG and it is related to its ability to set the period between pulses in 20 ns intervals. This delay is in addition to the inherent insertion delay.

EXTERNAL TRIGGER			
	IOC OPTIONS	**DESCRIPTION**	
Pulses per Trigger	Default: One pulse per Trigger	Standard mode of operation in external trigger. Every external trigger will generate only one gate pulse.	
	Advanced: Burst pulses per trigger:	The user can select for multiple pulses per trigger. The external trigger*generates the first pulse, subsequent pulses are generated internally by a user defined Period/Frequency.	
	Advanced: Burst/Fit pulses per Exposure	Software calculates the maximum number of pulses that can fit into the exposure. The external trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency. Any subsequent triggers that arrived within the exposure time are ignored.	

5.4.7 - Digital Delay Generator (DDG)

The New iStar's Digital Delay Generator **(DDG)** is built directly into the detector head. A trigger source (external trigger or internal trigger (Fire pulse)) activates the DDG, so that it can control the image intensifier for gating applications.

5.4.7.1 - Gater



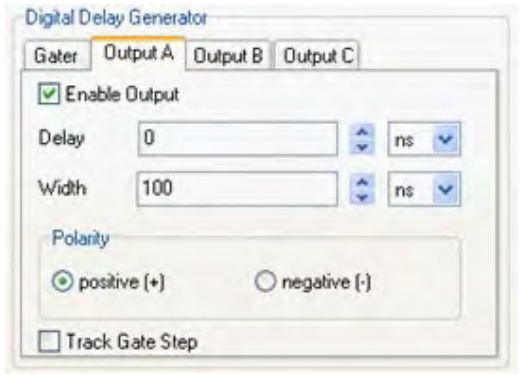
Gate Delay: The user can introduce a delay to the gate pulse in order to synchronise the opening of the image intensifier with an optical pulse. The range can be set from 0 to 10 s.

Gate Width: The user can enter the length of time the image intensifier is switched (or gated) On. Optical signal falls on the CCD sensor during this time. The range can be set from 0 to 10 s.

Resolution: 10 ps.

5.4.7.2 - Output A, B & C

The DDG can send out auxiliary output pulses called Output A, Output B, and Output C. These outputs are +5 V CMOS level with 50 Ω source impedance. They can drive 5 V into a non-terminating load or 2.5 V into 50 Ω load. The outputs can be used to synchronize triggers for auxiliary equipment, e.g. lasers, flash lamps or National Instrument™ hardware. It is recommended that these outputs be use as a trigger sources, rather than the Fire pulse, since they have better jitter performance with respect to the gate pulse. Fire pulse is best used as an indication of when the CCD expects to be exposed to light.



Delay: The user can configure the delay individually for each output - The range can be set from 0 to 10 s.

Width: The user can configure the width individually for each output - The range can be set from 2 ns to 10 s.

Resolution: 10 ps.

Polarity: Positive (low-high-low) or negative (high-low-high).

5.4.7.3 - Optical Width

When this option is selected in the **Gater** tab of the **Setup Acquisition** interface, the gate width becomes the factory measured actual optical gate width.

Note: Optical width versus electrical TTL widths is reported individually on the performance sheet of every New iStar.

5.4.7.4 - Gate Step

The **Gate Step** feature is available for use with the kinetic, photon counting, and fast kinetics acquisition modes. The first exposure in a series will use the gate delay specified. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. In this way the **Gate Step** feature causes the image intensifier to be 'gated on' progressively later (or earlier, if a negative value is entered) for each acquisition in the series.

Step

The user can enter a time which is added (or subtracted) incrementally to the gate delay during a series of acquisitions:

Variable

The user can also set up a variable gate step by selecting the **Variable** tick box on the gate step interface of the **Setup Gater** tab. The **Setup** button and the **Setup Variable Gate Step** dialog box will open, e.g.:

The **Variable Gate Step** option allows the user to configure the gate delay such that it changes in a variable fashion between each scan of a kinetic series. For example, it may be desirable to have a very short gate delay at the beginning of an acquisition and a much larger delay near the end. In this case it would be more suitable for the gate step to increase exponentially. Three options are selectable:

- Exponential
- Logarithmic
- Linear

If, for example, the user sets up a Kinetic Series to acquire four scans during the series, with an initial gate delay of 10,000 ps and with variable gate step conditions as shown in the dialog box below, then:

The gate pulse delay will be increased by a gate step of:

*1,000 + 5,000 * 1 = 6,000 ps after the first scan in the kinetic series (i.e. the gate delay changes to 16,000 ps)*

The Gate Delay will be increased by a further:

*1,000 + 5,000 * 2 = 11,000 ps after the second scan (i.e. the gate delay changes to 27,000 ps)*

and by:

*1,000 + 5,000 * 3 = 16,000 ps after the third scan (i.e. the gate delay changes to 43,000 ps)*

This means that the gate delay for the final scan in the series is 33,000 ps (6,000 + 11,000 + 16,000) larger than the gate delay for the first scan in the series.

Note: In fluorescence lifetime measurements, gate delay and gate step parameters can be set to allow a series of decay curves to be built up automatically.

Note: The Andor Basic command 'KineticSlice' allows the extraction of pixel/column signal intensity throughout a kinetic series, and plots this intensity versus time in a separate display window.

5.5 - TRIGGERING MODES

THE TRIGGERING MODES ARE SELECTED FROM A DROP-DOWN LIST ON THE **SETUP ACQUISITION** DIALOG BOX.

5.5.1 - Internal Trigger

Camera acts as a timing master for any external device, and also triggers both CCD and intensifier simultaneously. The camera determines the exact time when an exposure happens, based on the acquisition settings entered by the user.

To control an external device in time (e.g. a laser) output A, B or C can from the DDG should be used (see section 6 for details on setup).

5.5.2 - External Trigger

Camera waits for a trigger from an external device to perform the acquisition sequence, hence acting as a timing slave; both CCD and intensifiers are triggered simultaneously. Once an acquisition has been started, the camera is placed into a special cleaning cycle called "**External Keep Clean Cycle**" which ensures that charge build up on the CCD is kept to a minimum while waiting for the external trigger event. The external keep clean consists of a continuous sequence of one vertical shift followed by one horizontal shift. Once the External Trigger is received the current keep clean sequence is completed and the exposure phase initiated. The exact nature of the acquisition will depend on the user settings and is explained in more detail in a subsequent section. The external trigger is fed via the Ext Trig input on the camera head.

The maximum safe input levels are -0.3 to +5.0 V. The user can configure the following settings under the **Trigger** settings tab:

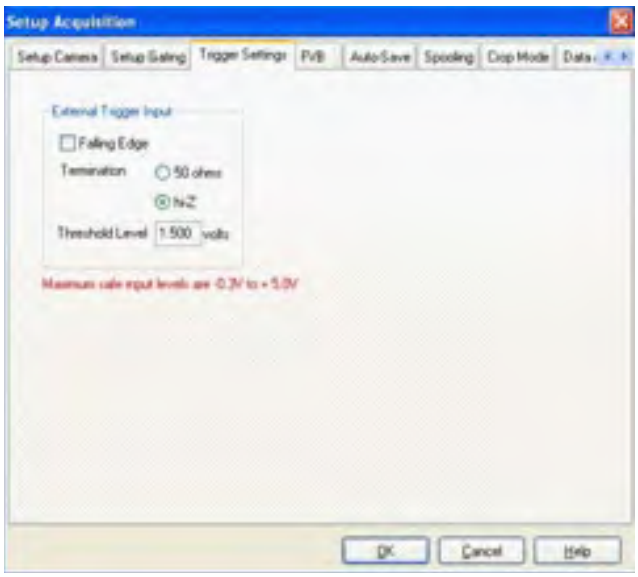
Termination: The input impedance can be change between High Impedance and 50 Ω.

Rising or Falling Edge Triggered: The system can be set to respond to rising edge or falling edge triggers.

Threshold Level: The trigger threshold can be programmed from +0.25 to +3.3 V.

When using external trigger the user may find it useful to monitor the Arm output at back of the detector head. When the Arm is high the system will accept external triggers.

For lowest jitter, the user may need to adjust the input impedance and/or trigger threshold to set the trigger level to the steepest part the input edge, typically 1/3 to 1/2 of the peak amplitude.

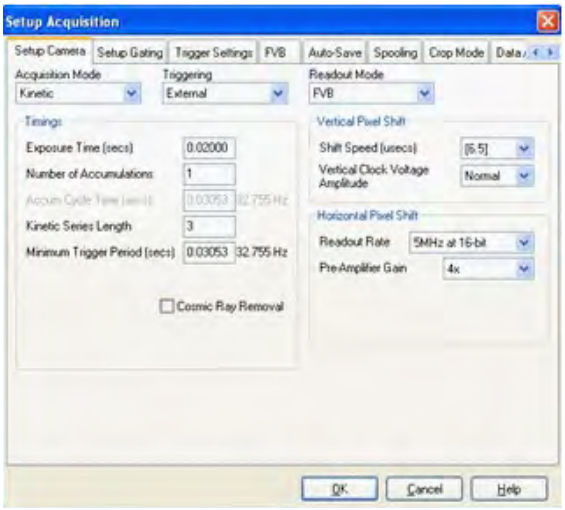


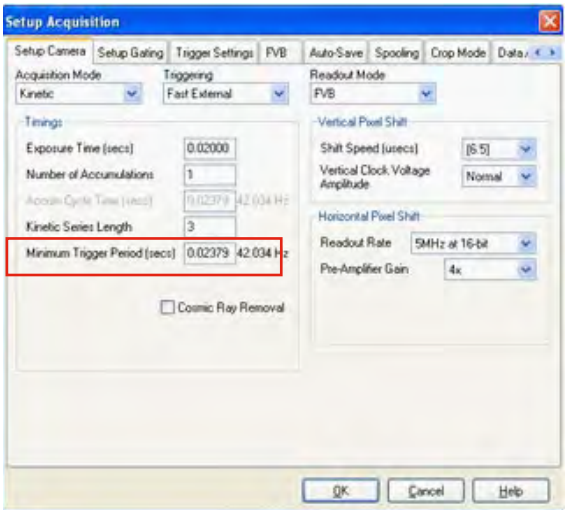
5.5.3 - Fast External

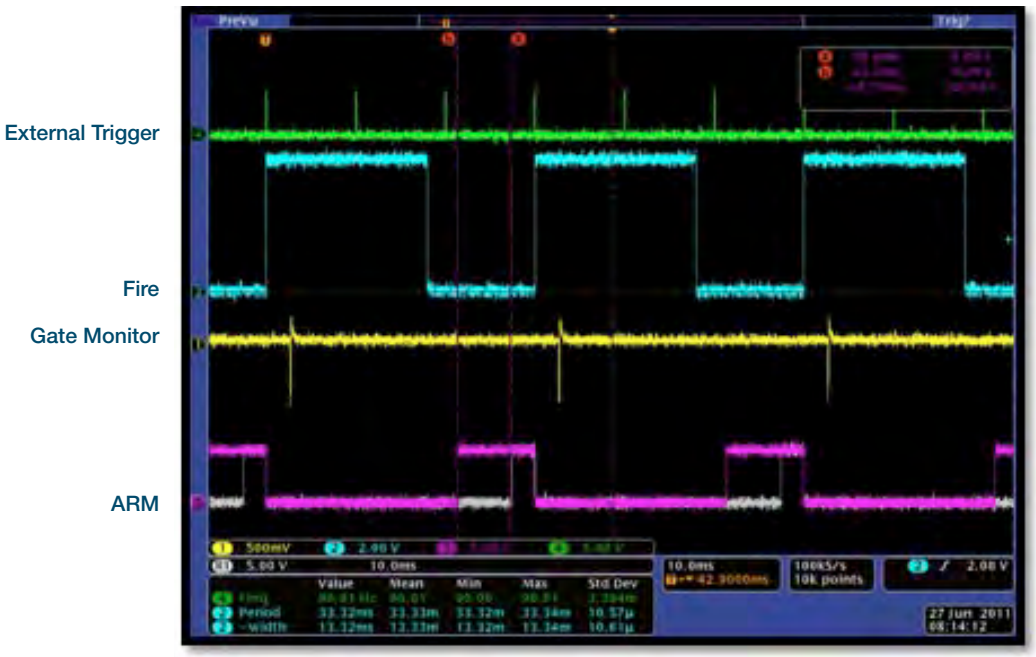
Fast External Trigger is for the most part identical to external trigger. It differs in only one key aspect. In fast external trigger the camera will not wait for a sufficient number of keep clean cycles to have been completed to ensure the image area is completely clean of charge before accepting an external trigger event, but instead will allow a trigger event to immediately start the acquisition process after performing a '1 vertical-1 horizontal, keep clean cycle'. As a result, fast external trigger allows a higher frame rate than standard external trigger.

The Arm is set low and the Fire pulse high approximately one 'keep clean cycle' later. If one is monitoring on the oscilloscope the external trigger with respect to the Fire pulse, the jitter of one 'keep clean cycle' will be seen. Note that the intensifier will open in response to that first external trigger and the jitter in the Fire pulse is not important. Also note that output A/B/C are available to offer lowest jitter between them and the external trigger and gate pulse.

The timings are the same as in external trigger mode, except that by removing the keep clean cycle the CCD can be triggered earlier as shown by the Arm waveform below.







5.5.4 - External Start

External Start is a mixture of External and Internal Trigger. In this mode the camera will perform a sequence of External Keep Clean Cycles while waiting for one external trigger event to occur and then start the acquisition process going. Once this external trigger event has occurred the camera will switch to internal trigger and the acquisition will progress as if the camera was in internal trigger mode.

SECTION 6 - OPERATION: GATING, TRIGGERING & SYNCHRONIZATION

6.1 - TRIGGERING: INTERNAL

6.1.1 - Acquisition Mode: Single

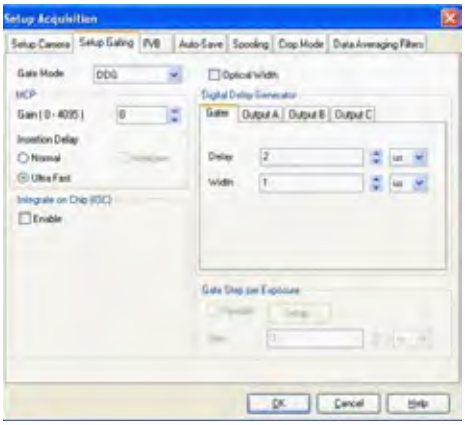
6.1.1.1- Standard Operation (IOC Disabled)

Description

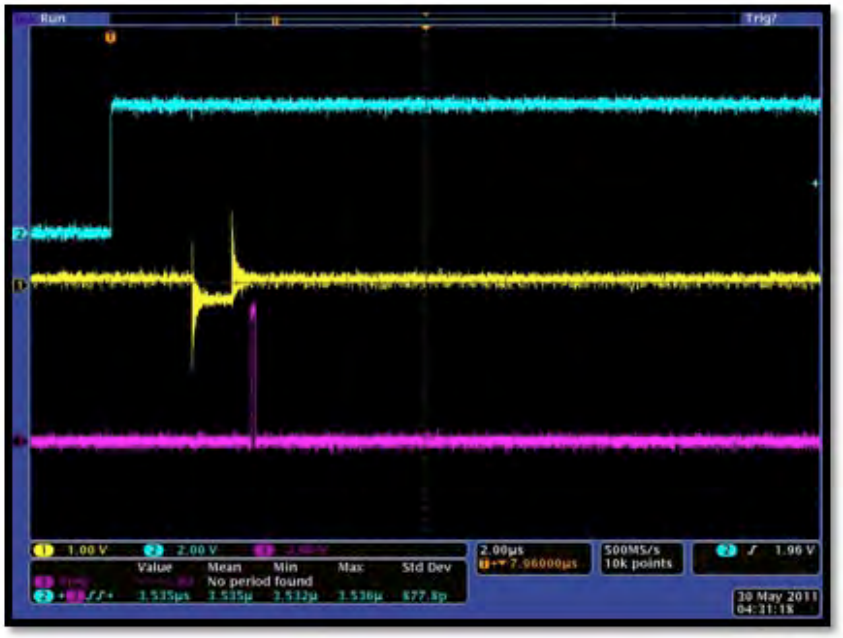
One gate pulse is generated within the exposure. A delay relative to the rising edge of the Fire pulse can be applied to the Gate pulse (and output A/B/C).

Setup

IOC disabled, output A enabled.



Waveforms



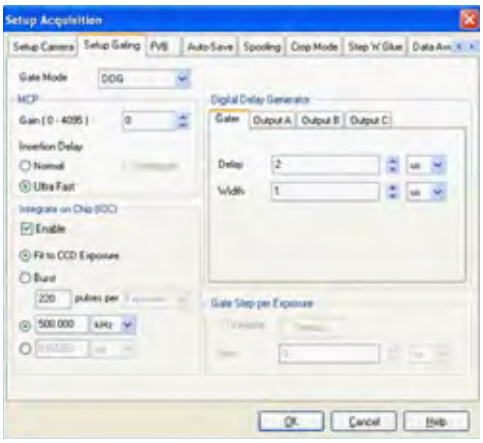
6.1.1.2 - Integrate On Chip (IOC) Enabled

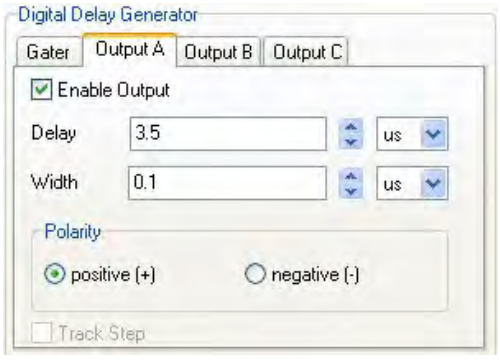
Description

Several gate pulses are generated within the exposure. A delay relative to the rising edge of the Fire pulse can be applied to the gate pulse (and output A/B/C).

Setup

IOC enabled, output A enabled.

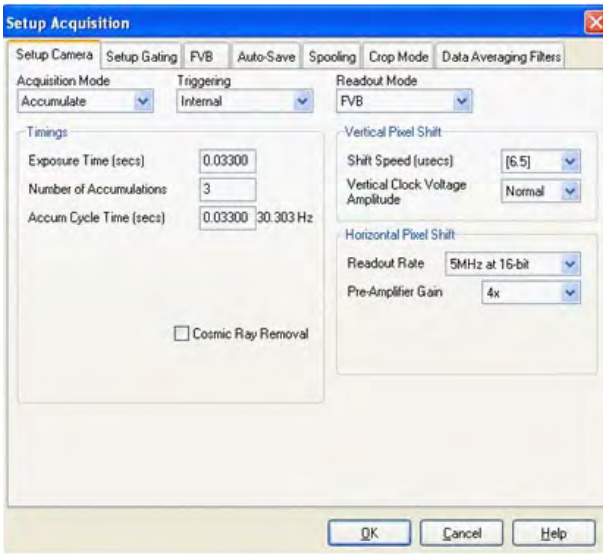




Waveforms

6.1.2 - Acquisition Mode: Accumulate

A number of individual frames will be added together to produce the final accumulated image.



6.1.2.1 - Standard Operation (IOC Disabled)

Description

One gate pulse is generated within an exposure. The gate delay is the same for each of the exposures involved.

Setup

IOC disabled, gate step disabled, output A enabled.

Waveforms

Timings are the same as in kinetic series: 1 accumulation, standard operation (IOC disabled and gate step disabled). See sections 6.1.3.1.1 and 6.1.3.2.1.

6.1.2.2 - Integrate on Chip (IOC)

Description

Several gate pulses are generated within each exposure. The gate delay is the same for each of the exposures.

Setup

IOC enabled, output A enabled.

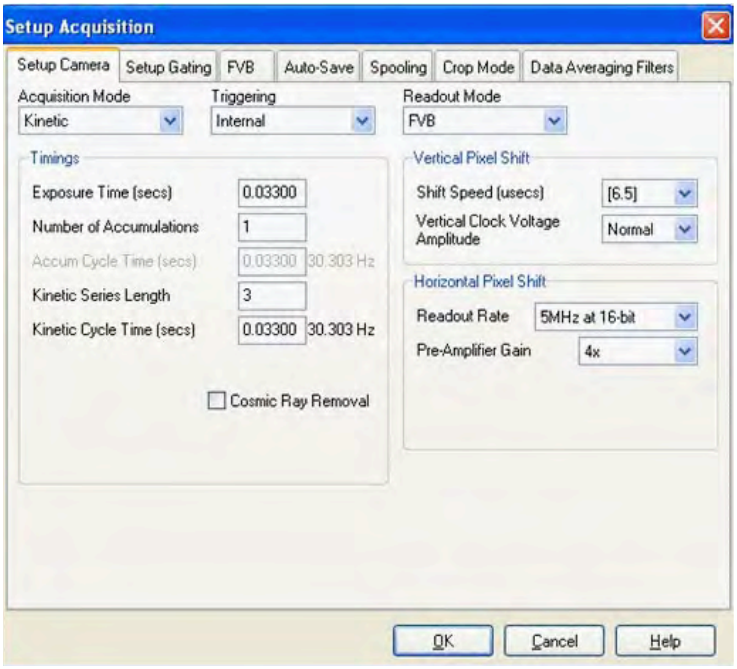
Waveforms

Timings are the same as in kinetic series: 1 accumulation, IOC enabled. See sections 6.1.3.1.2 and 6.1.3.2.2.

6.1.3 - Acquisition Mode: Kinetic

6.1.3.1 - Number of Accumulations = 1

A number of single images will be acquired in the series.



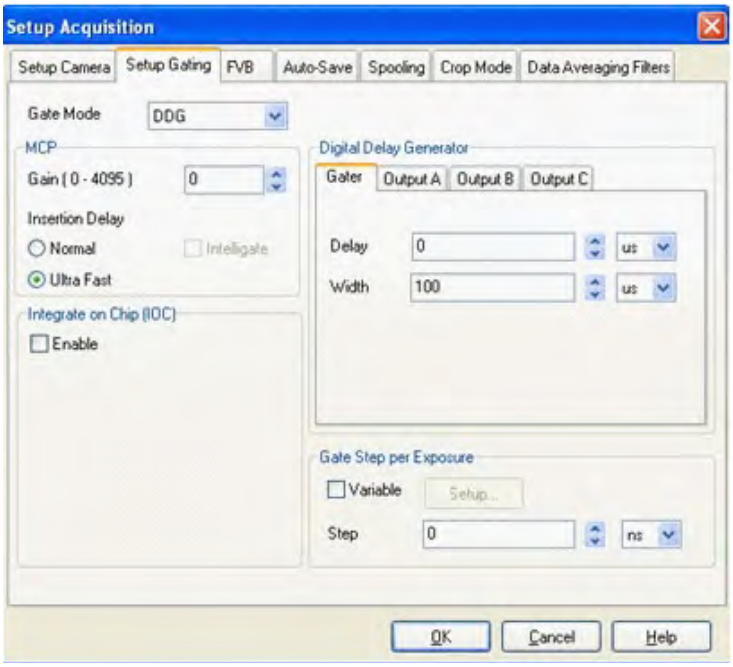
6.1.3.1.1 - Standard Operation (IOC Disabled and Gate Step Disabled)

Description

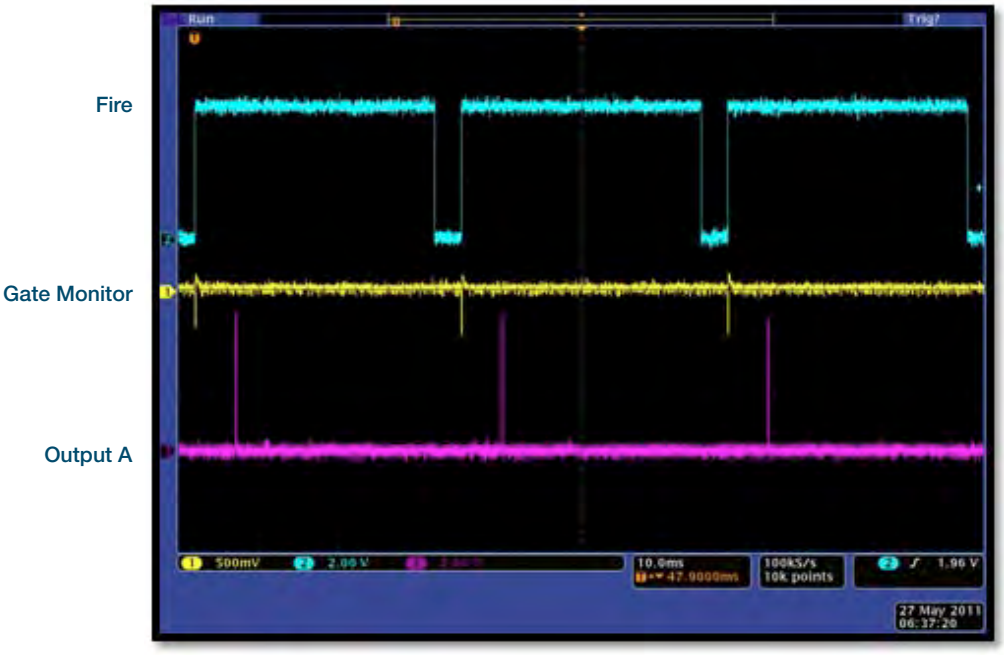
One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, output A enabled.



Waveforms



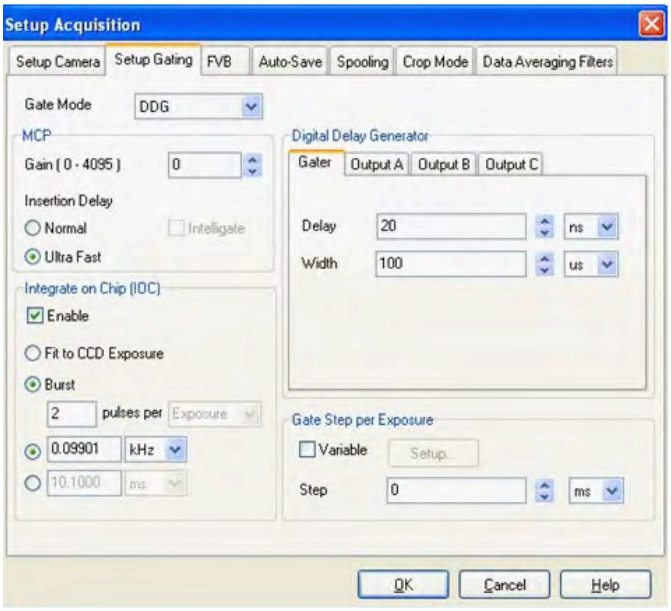
6.1.3.1.2 - Integrate on Chip (IOC) Enabled

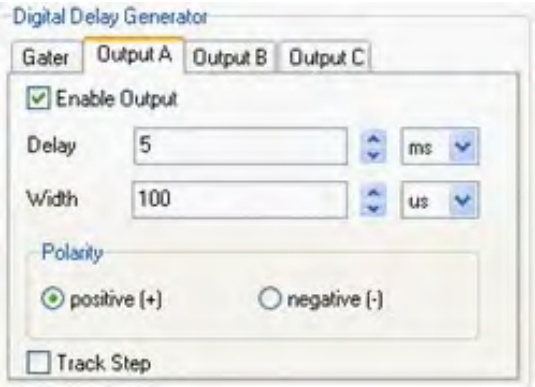
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

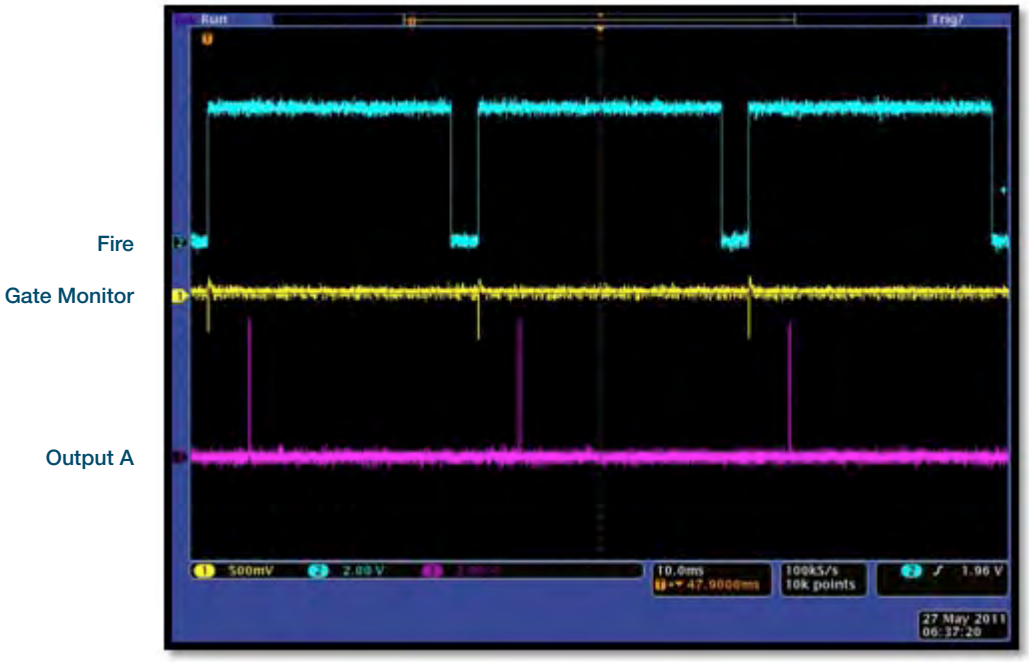
Setup

IOC enabled, Output A enabled.





Waveforms



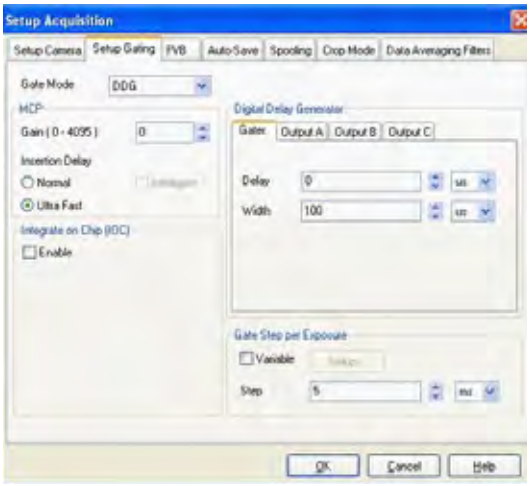
6.1.3.1.3 - Gate Step Enabled

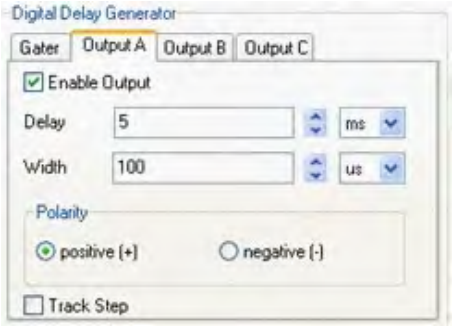
Description

One gate pulse is generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

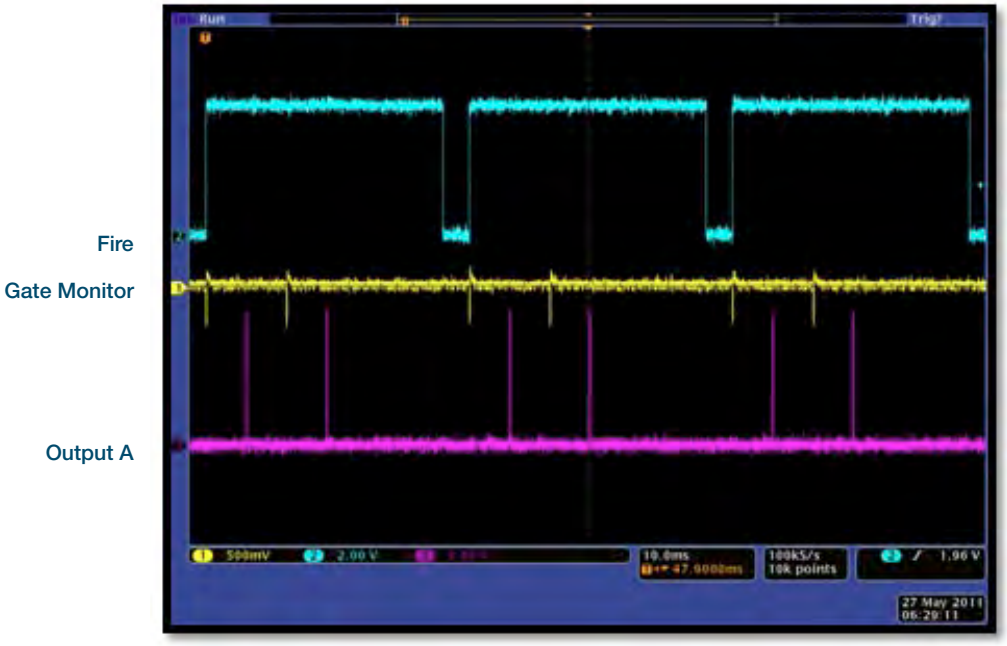
Setup

Gate step enabled, Output A enabled (trackstep disabled).





Waveforms



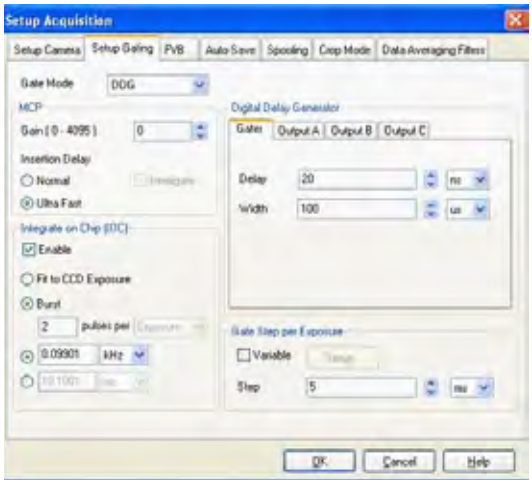
6.1.3.1.4 - IOC and Gate Step Enabled

Description

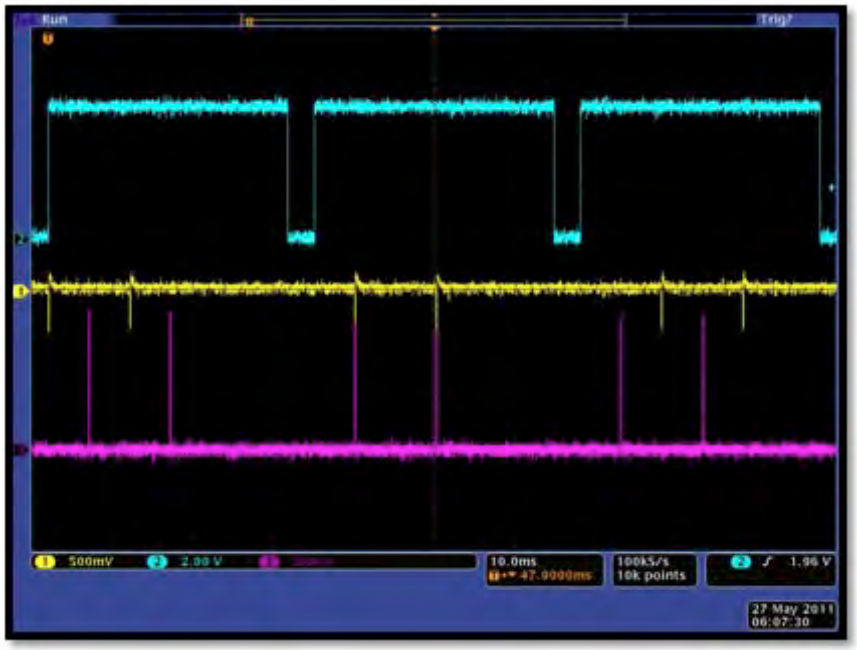
Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Setup

IOC enabled, gate step enabled, output A enabled (trackstep disabled).

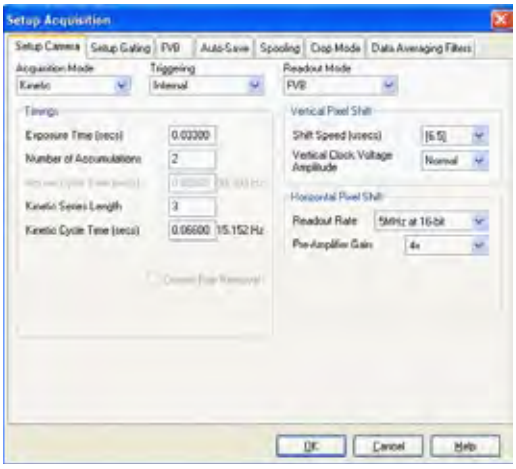


Waveforms



6.1.3.2 - Number of Accumulations > 1

A number of accumulated images will be acquired in the series.



6.1.3.2.1 - Standard Operation (IOC Disabled and Gate Step Disabled)

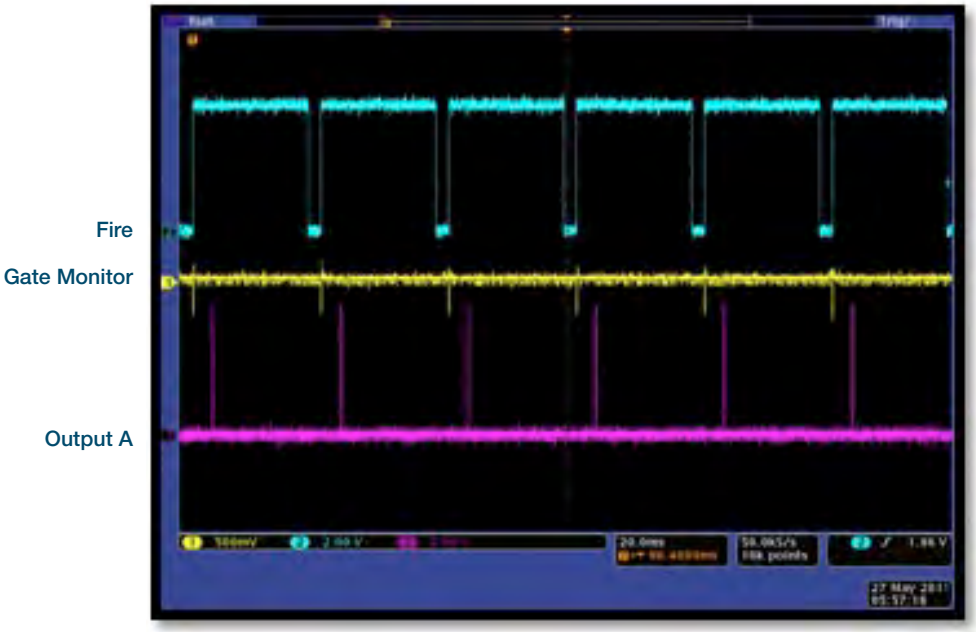
Description

One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned.

Setup

IOC disabled, gate step disabled, Output A enabled.

Waveform



6.1.3.2.2 - Integrate on Chip (IOC) Enabled

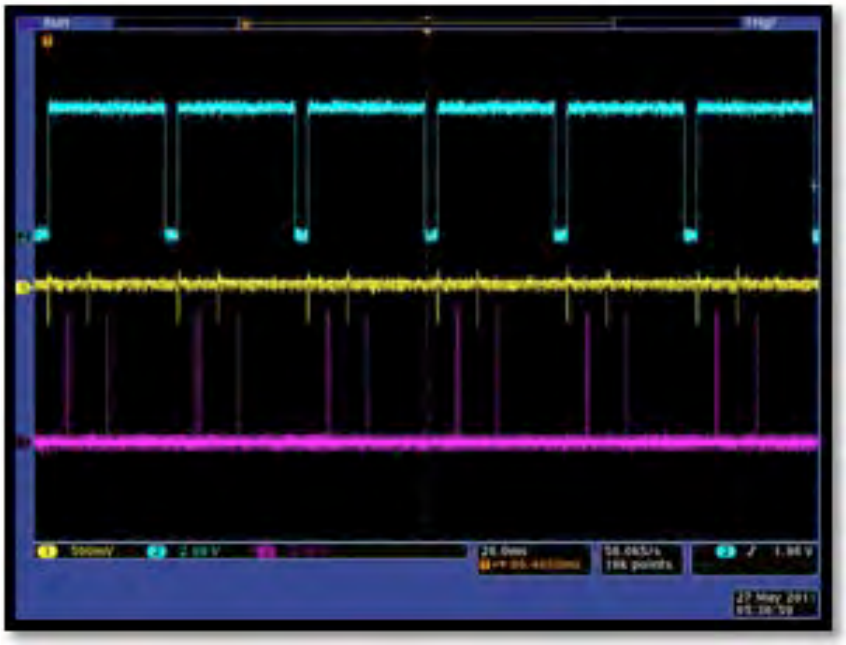
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned.

Setup

IOC enabled, Output A enabled.

Waveforms



6.1.3.2.3 - Gate Step Enabled

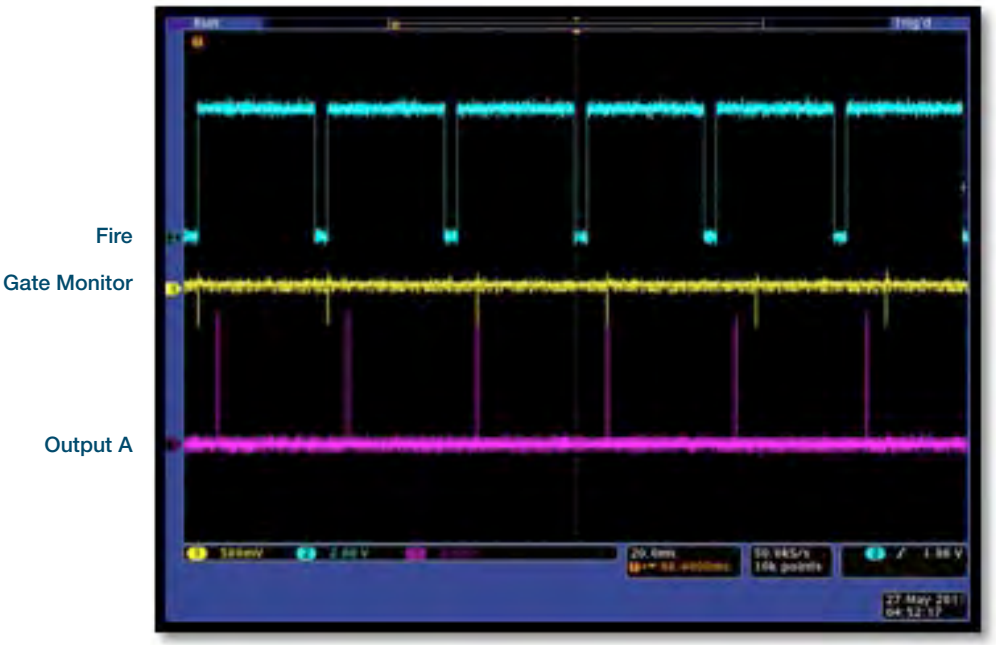
Description

One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned.

Setup

Gate step enabled, Output A enabled (trackstep disabled).

Waveforms



6.1.3.2.4 - IOC and Gate Step Enabled

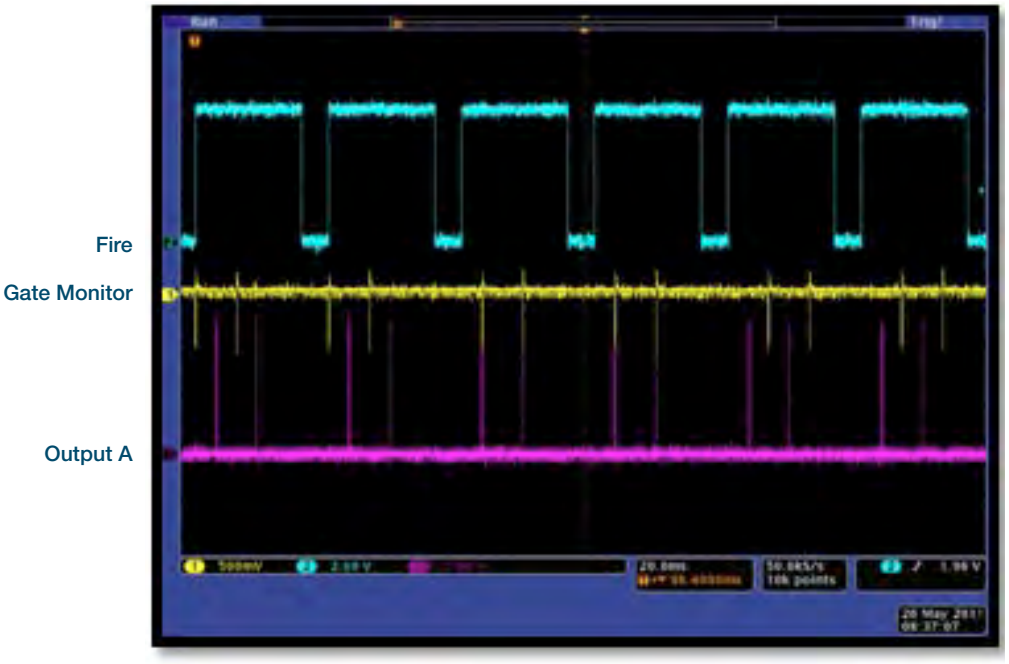
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned.

Setup

IOC enabled, gate step enabled, output A enabled (trackstep disabled).

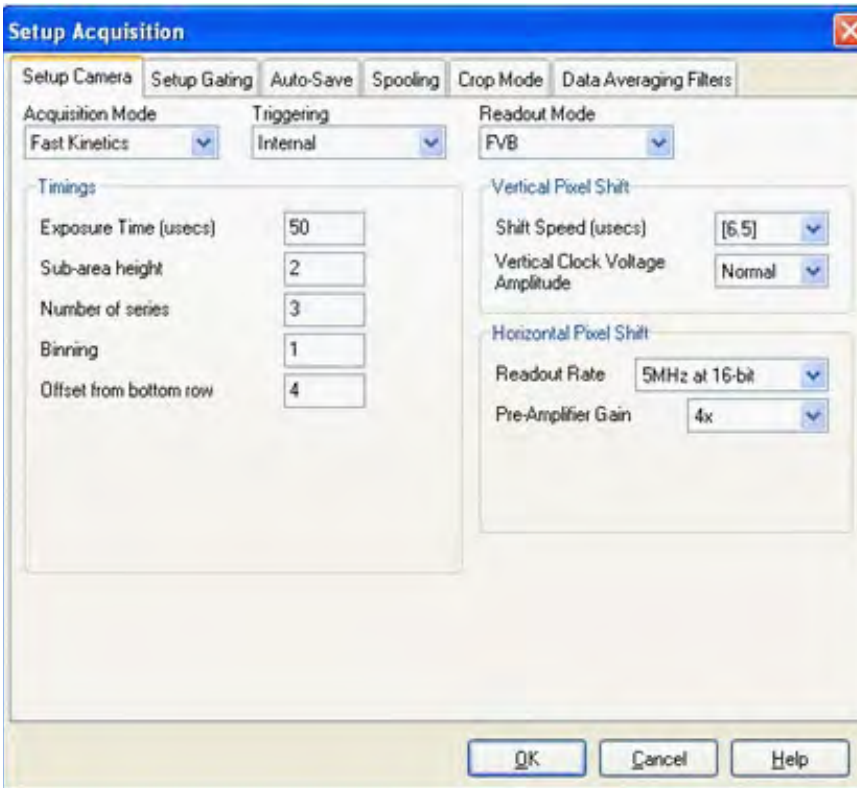
Waveforms



6.1.4 - Acquisition Mode: Photon Counting

Same as Acquisition Mode: Kinetic operation. Please refer to section 5.3.1.6 to set up the appropriate counting thresholds.

6.1.5 - Acquisition Mode: Fast Kinetics



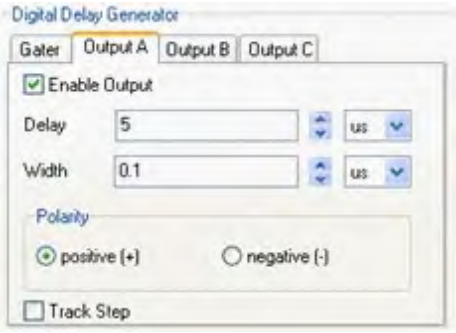
6.1.5.1 - Standard Operation (IOC Disabled and Gate Step Disabled)

Description

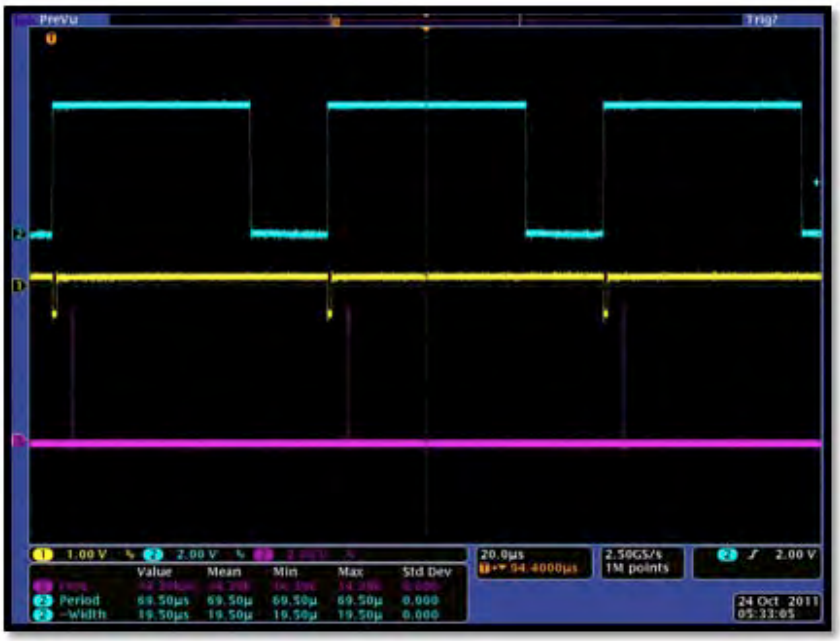
One gate pulse is generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, Output A enabled.



Waveforms



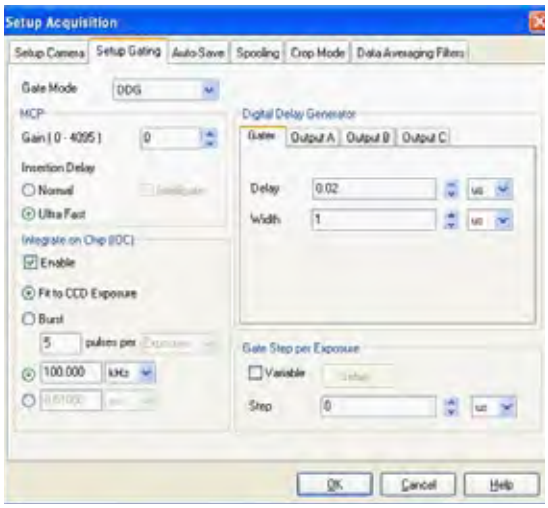
6.1.5.2 - Integrate on Chip (IOC) Enabled

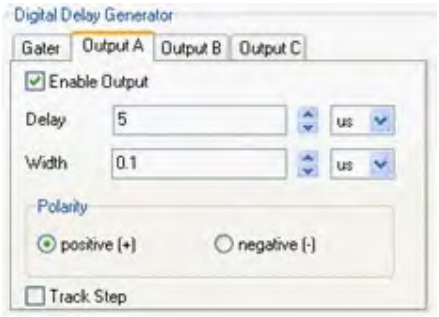
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series.

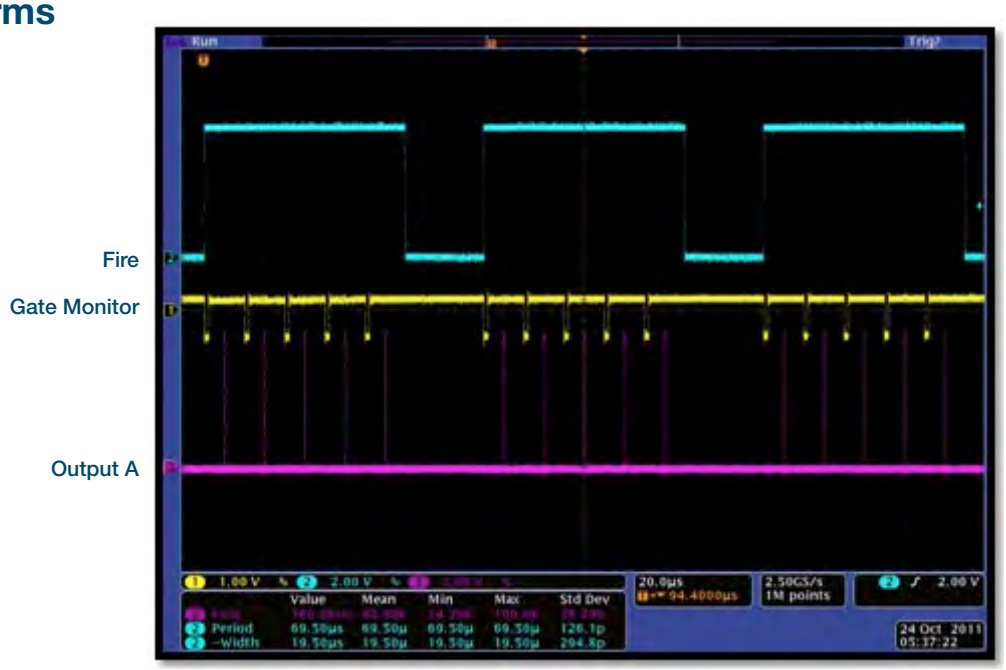
Setup

IOC enabled, Output A enabled.





Waveforms



6.1.5.3 - Gate Step Enabled

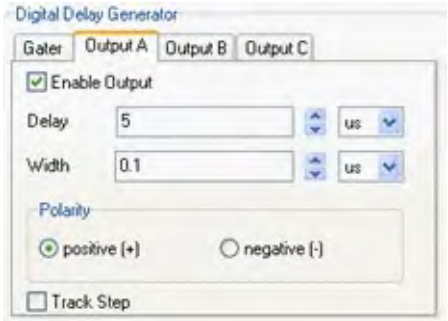
Description

One gate pulse is generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

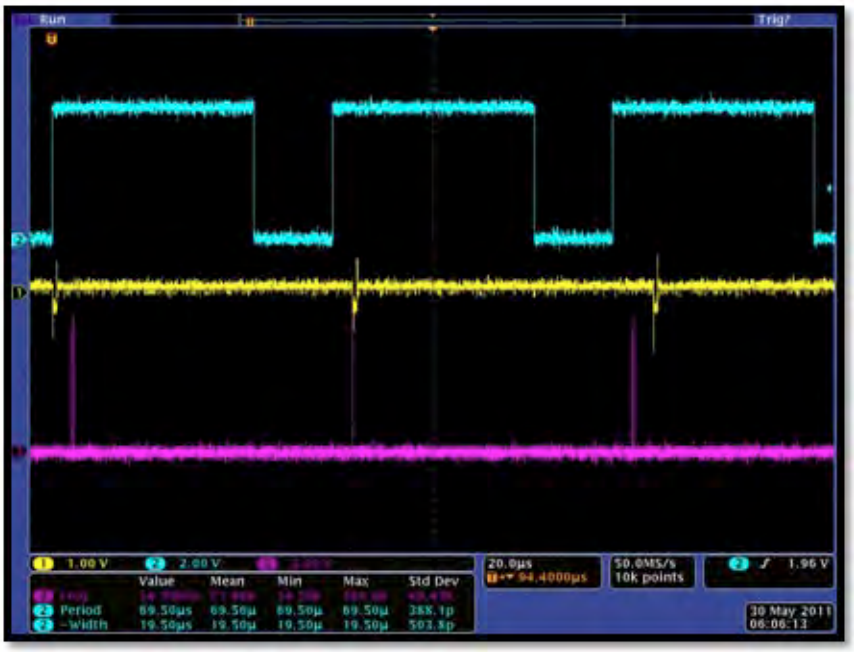
The fire pulse rate cannot exceed 15 kHz in this particular mode.

Setup

Gate step enabled, Output A enabled (trackstep disabled).



Waveforms



6.1.5.4 - IOC and Gate Step Enabled

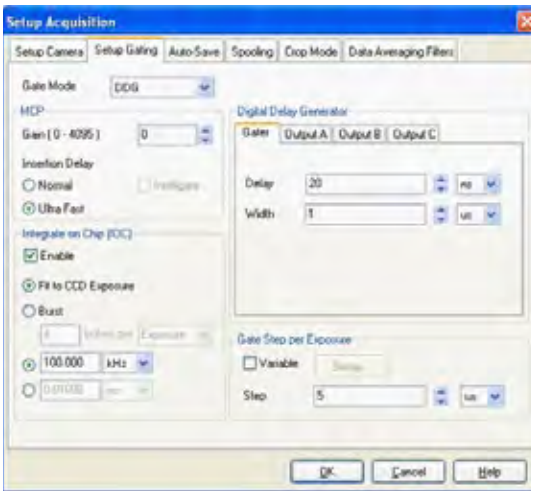
Description

Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

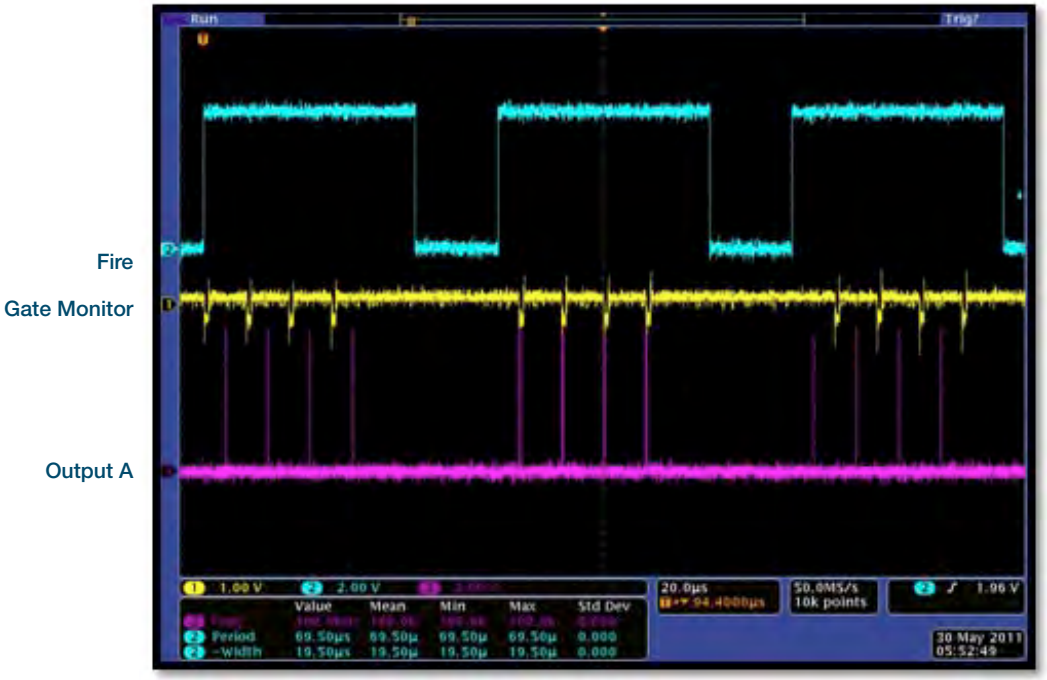
The fire pulse rate cannot exceed 15 kHz in this particular mode.

Setup

IOC enabled, gate step enabled, Output A enabled (trackstep disabled).



Waveforms



6.2 - TRIGGERING: EXTERNAL

6.2.1 - Acquisition Mode: Single

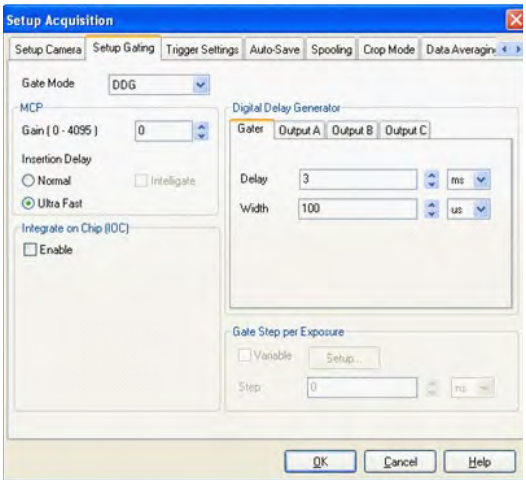
6.2.1.1 - Standard Operation (IOC Disabled)

Description

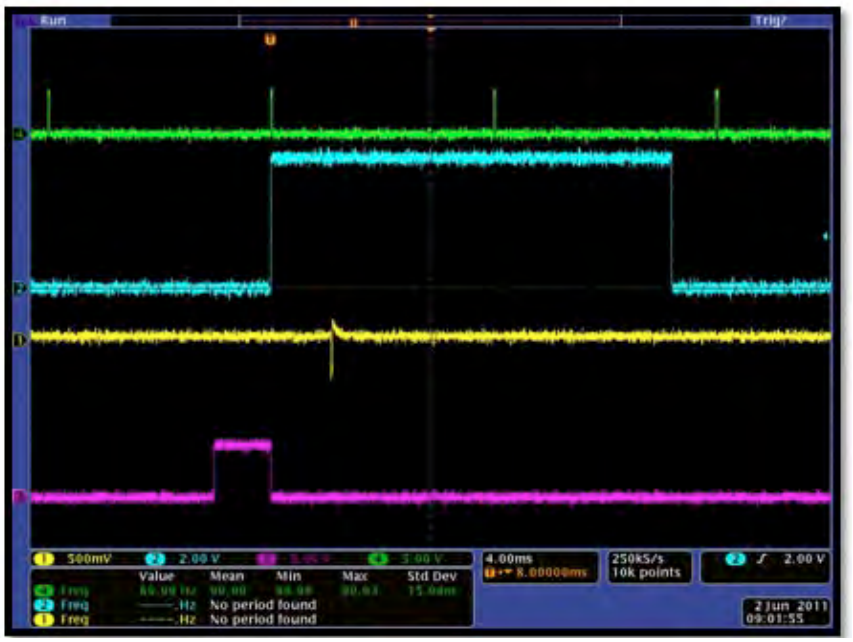
The external trigger generates one gate pulse per exposure. A delay relative to the trigger can be applied to the gate pulse (and output A/B/C). Any subsequent triggers that arrive during the exposure are ignored.

Setup

IOC disabled.



Waveforms



6.2.1.2 - Integrate on Chip (IOC) Enabled

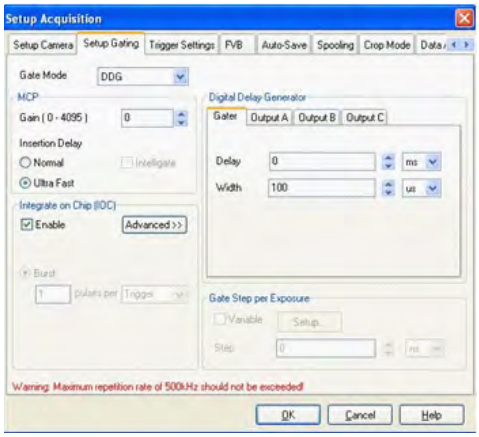
6.2.1.2.1 - Default: One Pulse per Trigger

Description

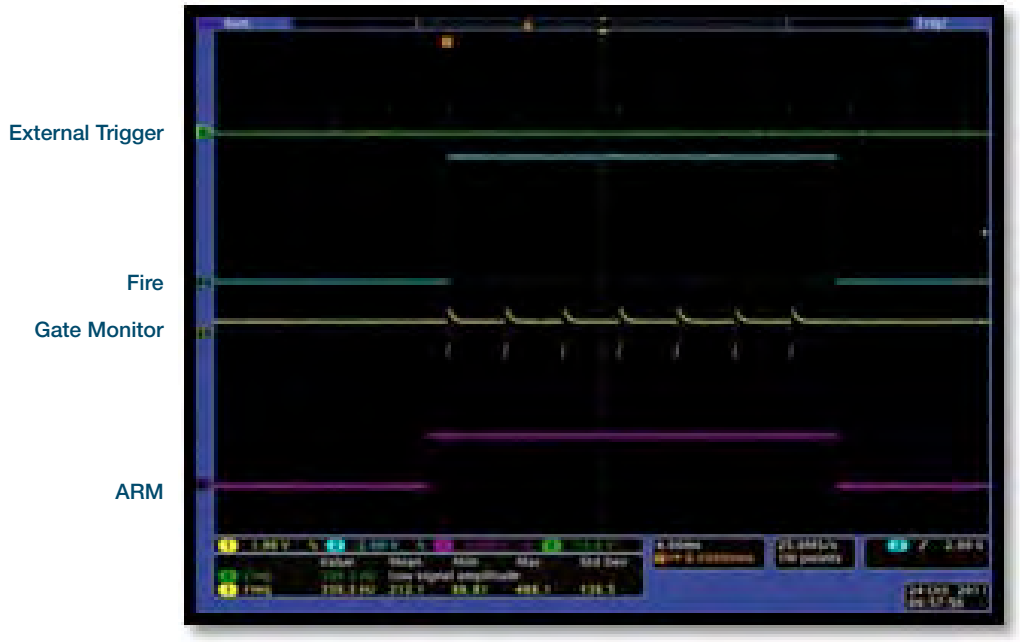
This is the standard mode of operation in external trigger. Every external trigger within an exposure will generate only one gate pulse. A gate delay is applied that is the same per every trigger within an exposure.

Setup

IOC enabled, output A/B/C disabled.



Waveforms

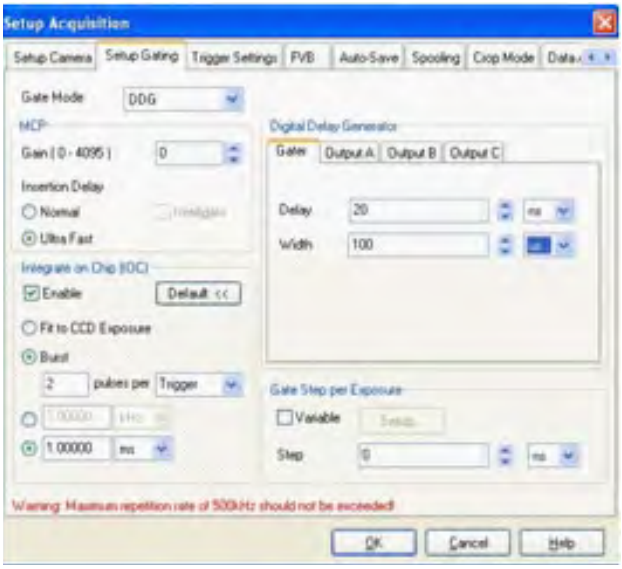


One Pulse per Trgger

6.2.1.2.2 - Advanced: Burst of Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The external trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency.



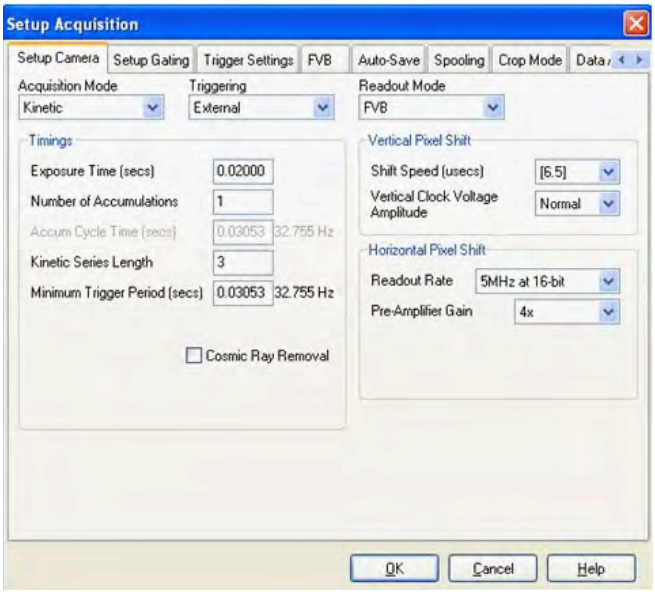
Waveforms

Burst per Trgger

6.2.2 - Acquisition Mode: Kinetic

6.2.2.1 - Number of Accumulations = 1

A number of single images will be acquired in the series.



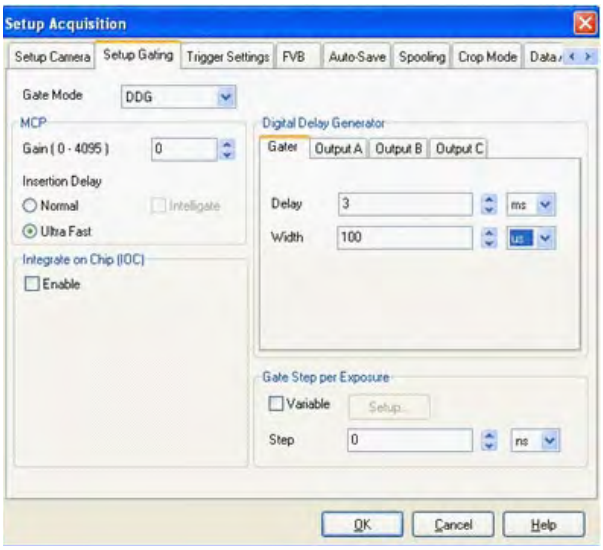
6.2.2.1.1 - Standard Operation (IOC Disabled and Gate Step Disabled)

Description

The external trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, output A/B/C disabled.



Waveforms

6.2.2.1.2 - Integrate on Chip (IOC) Enabled

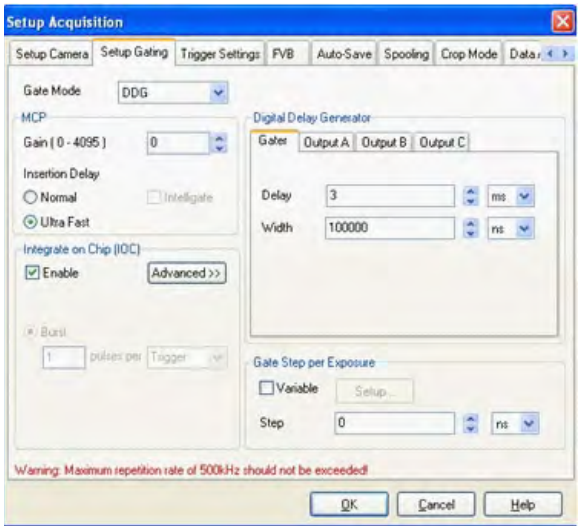
6.2.2.1.2.1 - Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an exposure. Every external trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, output A/B/C disabled.



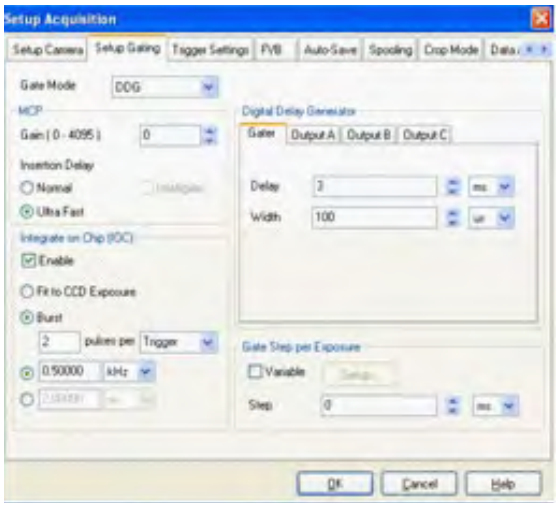
Waveforms

One Pulse per Trgger

6.2.2.1.2.2 - Advanced: Burst Pulses per Trigger

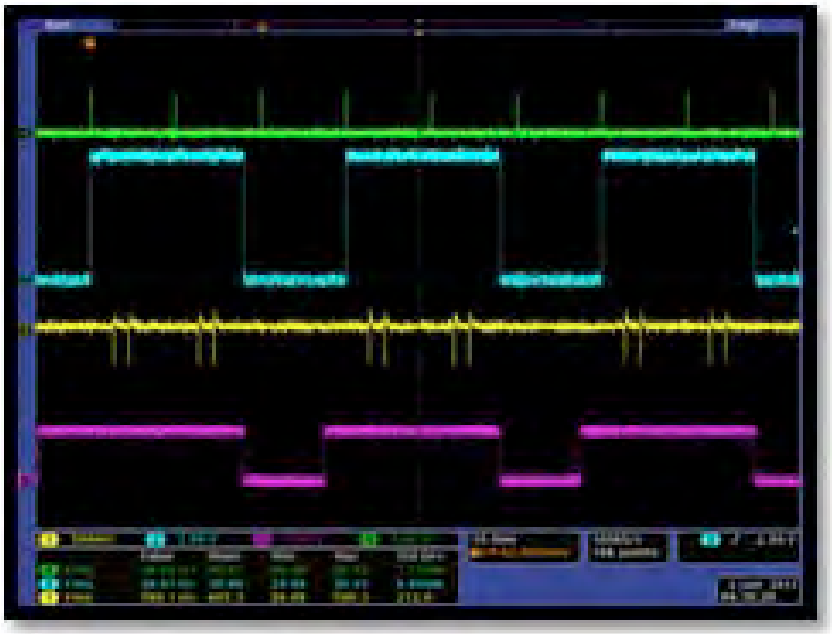
Description

The user can select multiple pulses per trigger. The external trigger generates the first pulse, and subsequent pulses are generated internally by a user defined period/frequency.



Burst per Trigger

Waveforms



6.2.2.1.2.3 - Advanced: Burst/Fit Pulses per Exposure

Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series. For each exposure, the external trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure or the user defines the number of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.

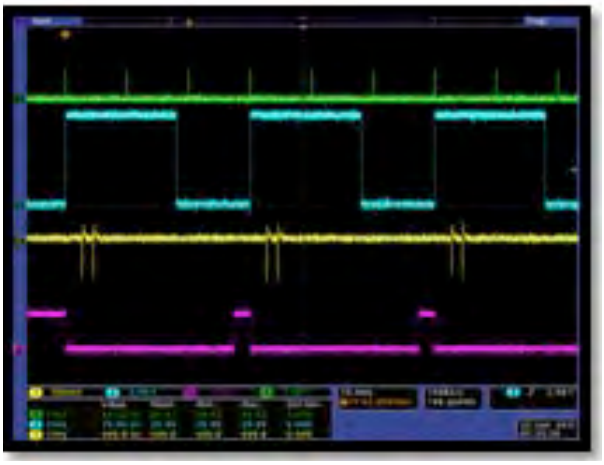
Waveforms

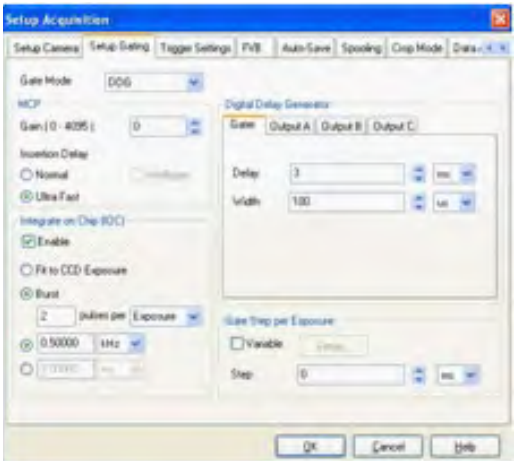
External Trigger

Fire

Gate Monitor

ARM





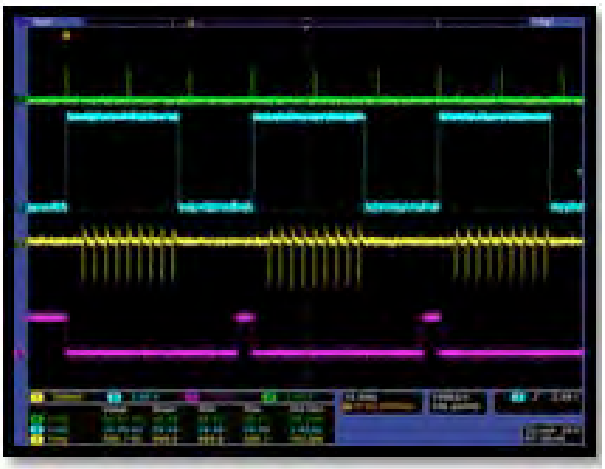
Burst per Exposure

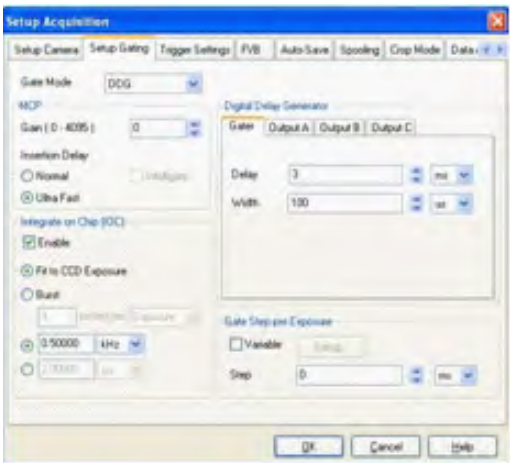
External Trigger

Fire

Gate Monitor

ARM





Fit to CCD Exposure

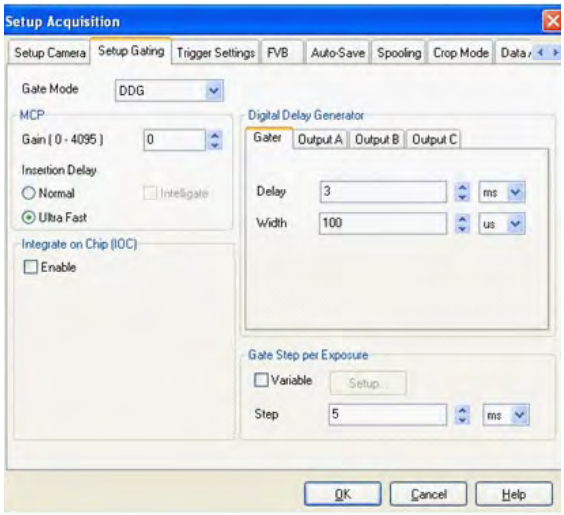
6.2.2.1.3 - Gate Step Enabled

Description

The external trigger generates one gate pulse per exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

Setup

Gate step enabled, output A/B/C disabled.



Waveforms

6.2.2.1.4 - IOC and Gate Step Enabled

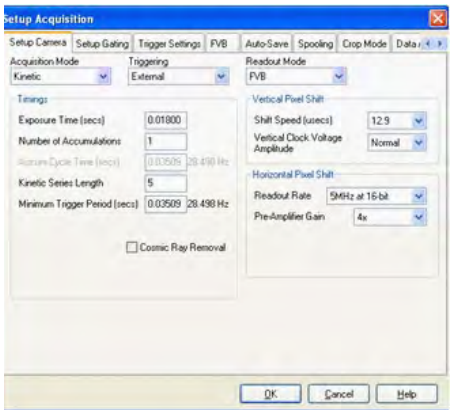
6.2.2.1.4.1 - Default: One Pulse per Trigger

Description

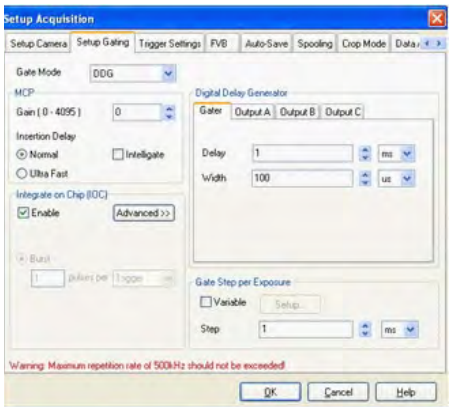
Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. Every external trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, gate step, output A/B/C disabled.



CCD Settings



One pulse trigger

Waveforms

Limitations

WhEN USING EXTERNAL TRIGGER WITH IOC AND GATE STEP THE SOFTWARE HAS TO COMMUNICATE TO THE DDG IN BETWEEn scans in order to increment the gate delay. The time needed is :

- **7.5 ms** when incrementing the gate delay
- **11.5 ms** when incrementing the gate delay, output A delay, output B delay, output C delay (if track gate step is enabled)

This time is in most cases less than the time it takes to clean out the image area before each exposure. **Therefore precautions only need to be taken when the time to clean out the image area is less than 7.5 ms (or 11.5 ms if other channels are tracking the gate step)**. Since this clean cycle depends on the sensor and vertical shift speed combination the table below shows the recommended settings. Unless stated otherwise the maximum trigger rate is to 500 kHz (5 khz for intelligate).

a) When incrementing the gate delay only:

When using trigger rates **less than 133 Hz,** the recommended setup is:

	Vertical Shift Speed (µsecs)
DH334T (47-10 sensor)	6.5
DH320T (30-11 sensor)	11.3
DH340T (42-10 sensor)	12.9
DH312T (77-00 sensor)	6.5

When using trigger rates **greater than 133 Hz,** the recommended setup is:

	Vertical Shift Speed (µsecs)	Clean Cycle (msecs) for information only
DH334T (47-10 sensor)	6.5	13.5
DH320T (30-11 sensor)	22.5	9.3
DH340T (42-10 sensor)	12.9	10
DH312T (77-00 sensor)	12.9	8.8

b) When incrementing the gate delay, output A delay, output B delay, output C delay, and track gate step is enabled

When using trigger rates **less than 87 Hz**, the recommended setup is:

	Vertical Shift Speed (µsecs)
DH334T (47-10 sensor)	6.5
DH320T (30-11 sensor)	11.3
DH340T (42-10 sensor)	12.9
DH312T (77-00 sensor)	6.5

When using trigger rates **greater than 87 Hz**, the recommended setup is:

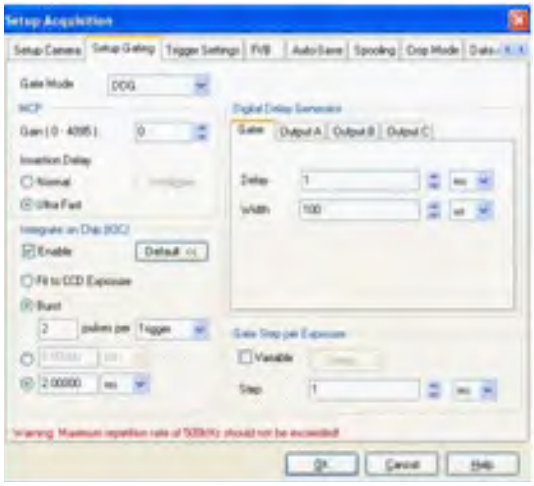
	Vertical Shift Speed (µsecs)	clean cycle (msecs) for information only
DH334T (47-10 sensor)	6.5	13.5
DH320T (30-11 sensor)	22.5 (107 Hz maximum) ⚠	9.3
DH340T (42-10 sensor)	25.7	16.6
DH312T (77-00 sensor)	25.7	15.4

Note: This mode is not supported in fast external trigger or when using fast kinetics. However IOC and gate step are available in internal trigger mode.

6.2.2.1.4.2 - Advanced: Burst Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The external trigger generates the first pulse, subsequent pulses are generated internally by a user defined Period/Frequency. A gate delay is applied that is the same per every trigger within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.



Waveforms

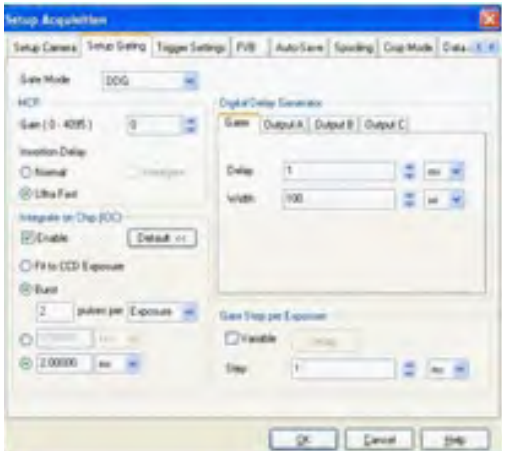
Burst per Exposure

6.2.2.1.4.3 - Advanced: Burst/Fit Pulses per Exposure

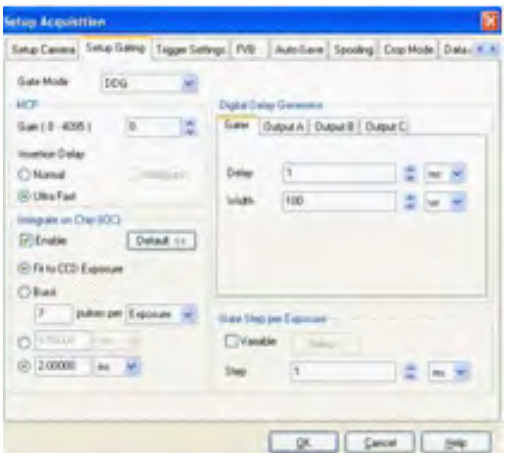
Description

Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. For each exposure, the external trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure, given the final gate delay in the series, or the user defines the number of pulses per exposure. Any subsequent triggers that arrive during the exposure.

Waveforms

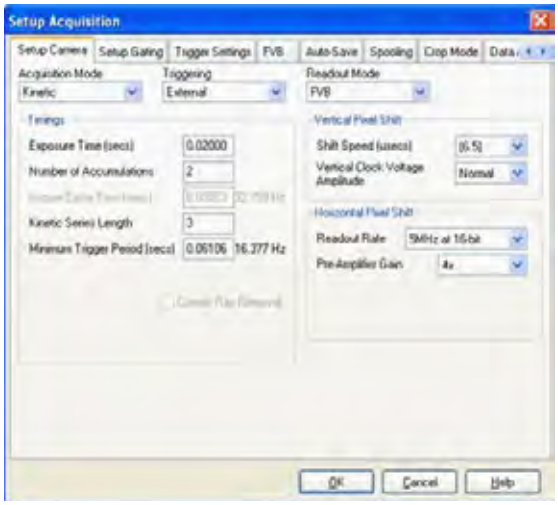


Burst per Exposure



Fit to CCD Exposure

6.2.2.2 - Number of Accumulations > 1



6.2.2.2.1 - Standard Operation (IOC Disabled and Gate Step Disabled)

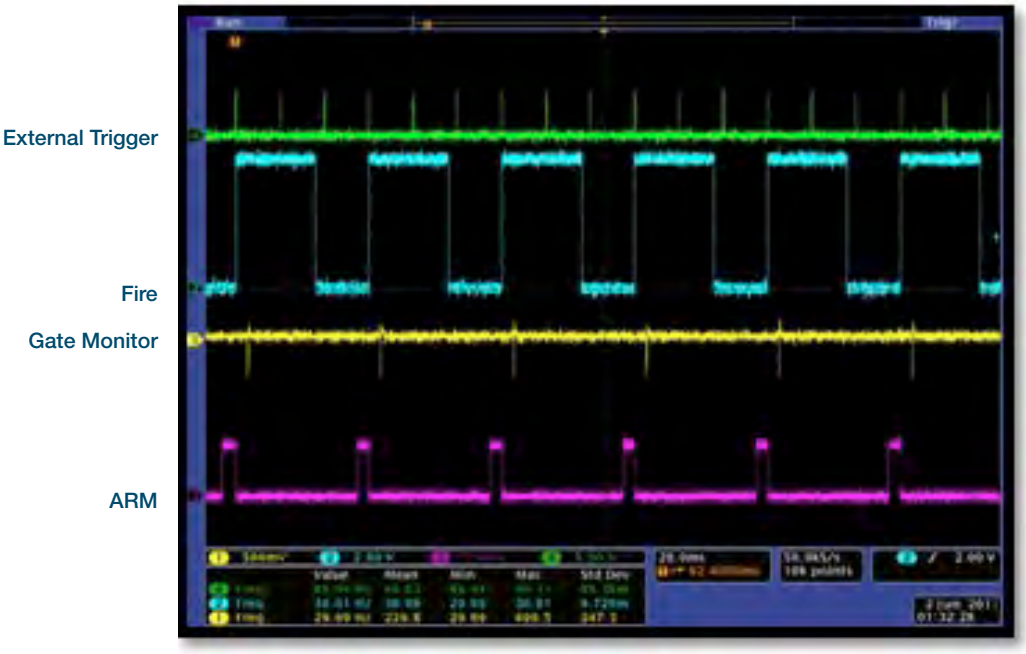
Description

The external trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned.

Setup

IOC disabled, gate step disabled, output A/B/C disabled.

WAVEFORMS



6.2.2.2.2 - Integrate on Chip (IOC) Enabled

6.2.2.2.2.1 - Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an accumulated image. The gate delay is also the same for every accumulated image that is returned. Every external trigger within an exposure will generate only one gate.

Setup

IOC enabled, output A/B/C disabled.

Waveforms

External Trigger

Fire

Gate Monitor

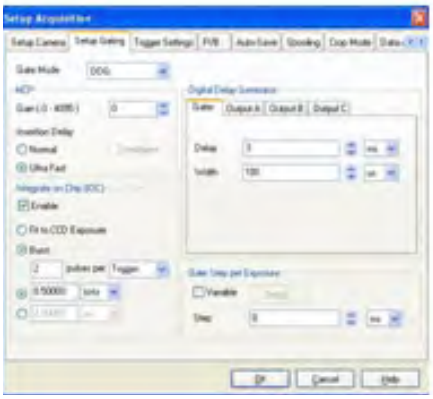
ARM

One Pulse per Trigger

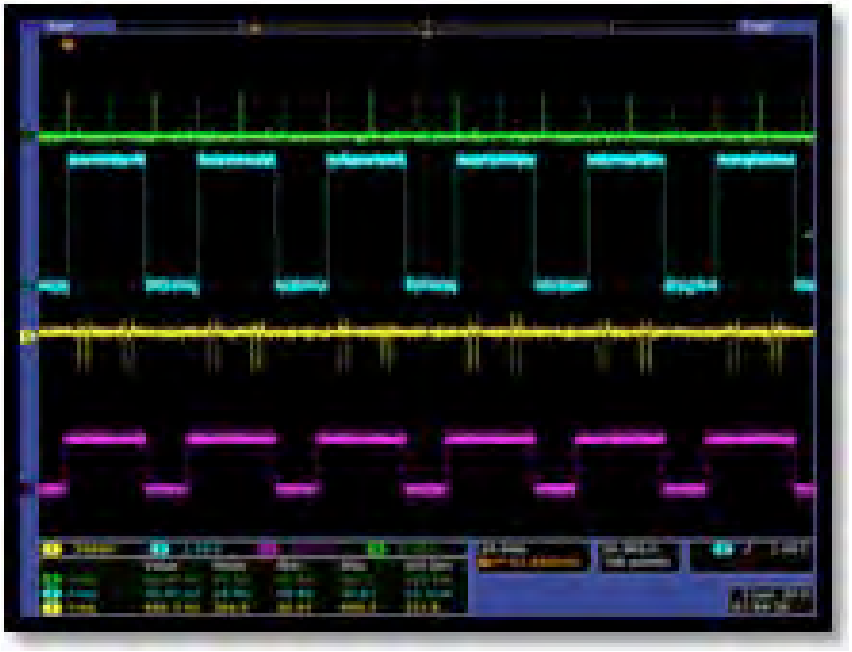
6.2.2.2.2.2 - Advanced: Burst Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The external trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency.



Waveforms



Burst per Trigger

6.2.2.2.2.3 - Advanced: Burst/Fit Pulses per Exposure

Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is also the same for every accumulated image that is returned. For each exposure, the external trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses that can fit into the exposure is applied, or alternatively the user defines the numbers of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.

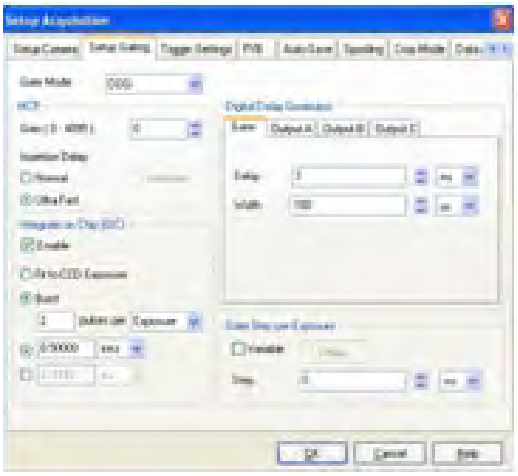
Waveforms

External Trigger

Fire

Gate Monitor

ARM



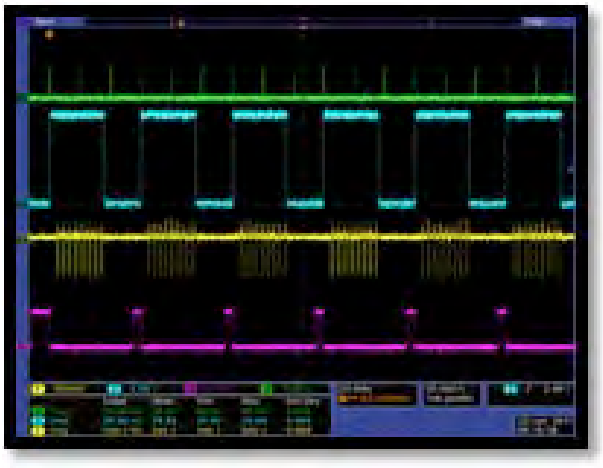
Burst per Exposure

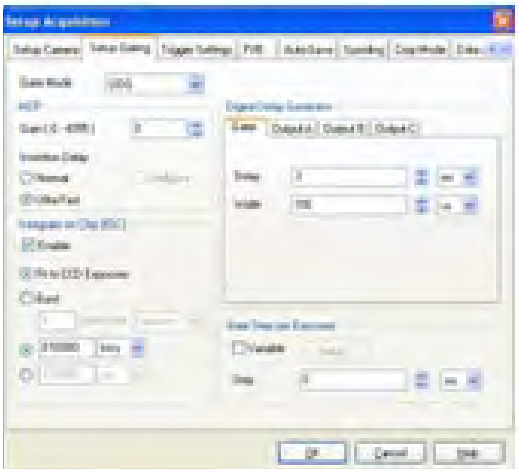
External Trigger

Fire

Gate Monitor

ARM





Fit to CCD Exposure

6.2.2.2.3 - Gate Step Enabled

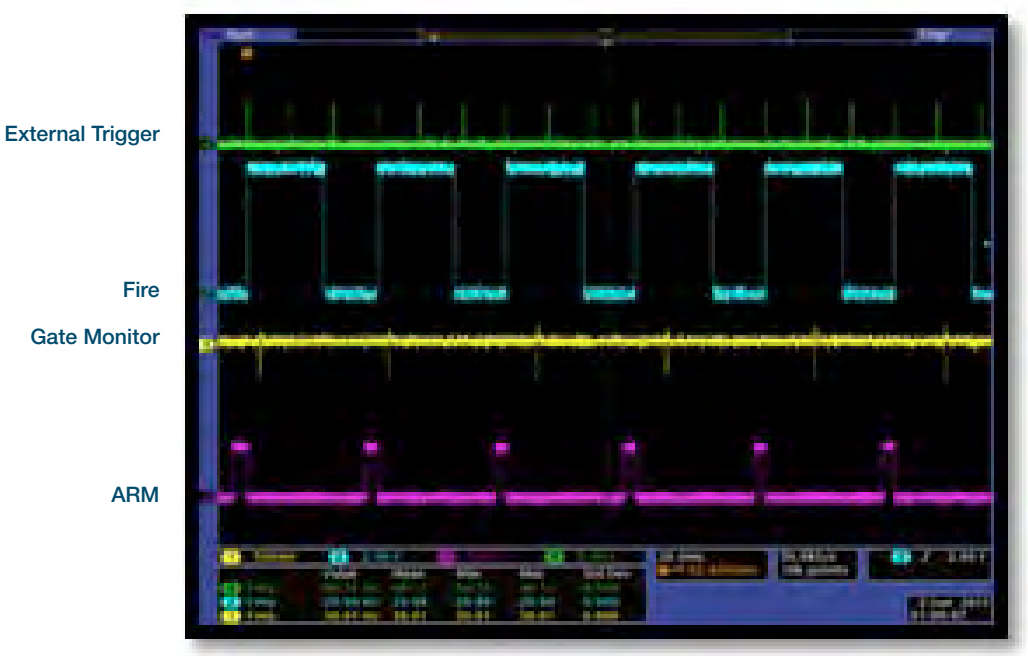
Description

The external trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned.

Setup

Gate step enabled, output A/B/C disabled.

Waveforms



6.2.2.2.4 - IOC and Gate Step Enabled

6.2.2.2.4.1 - Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an accumulated image. The gate delay is incremented for every accumulated image that is returned .Every external trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, gate step enabled, output A/B/C disabled.

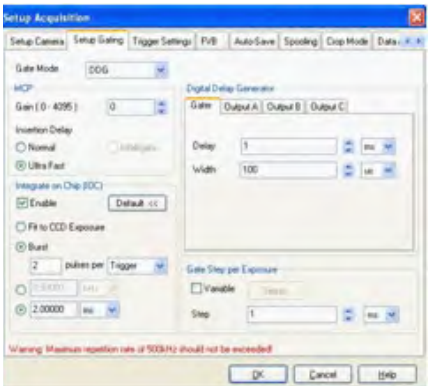
Waveforms

One Pulse per Trigger

6.2.2.2.4.2 - Advanced: Burst Pulses per Trigger

Description

The user can select for multiple pulses per trigger. The external trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency. A gate delay is applied that is the same per every trigger within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.



Burst per Trigger

6.2.2.2.4.3 - Burst/Fit Pulses per Exposure

Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure within an accumulated image. The gate delay is incremented for every accumulated image that is returned. For each exposure, the external trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure, given the final gate delay in the series, or the user defines the numbers of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.

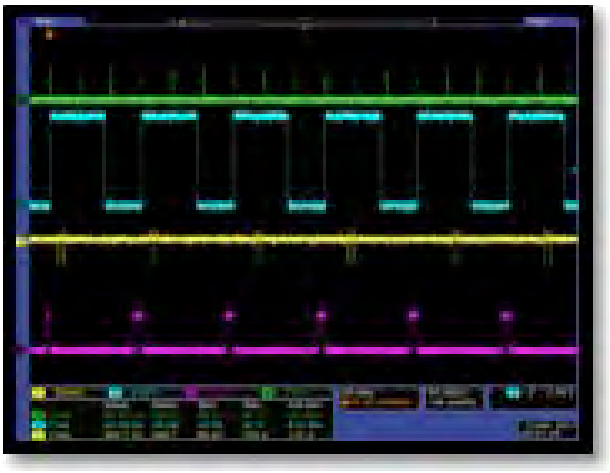
Waveforms

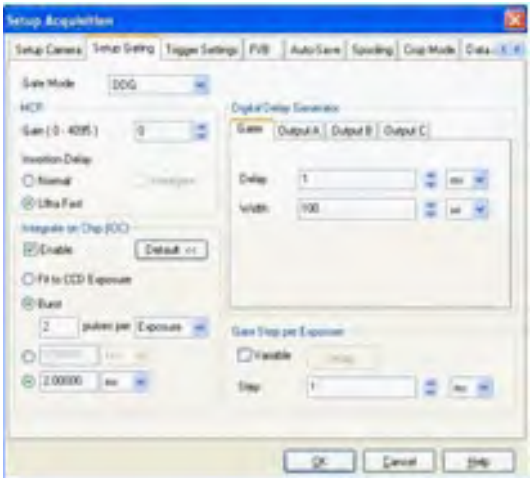
External Trigger

Fire

Gate Monitor

ARM





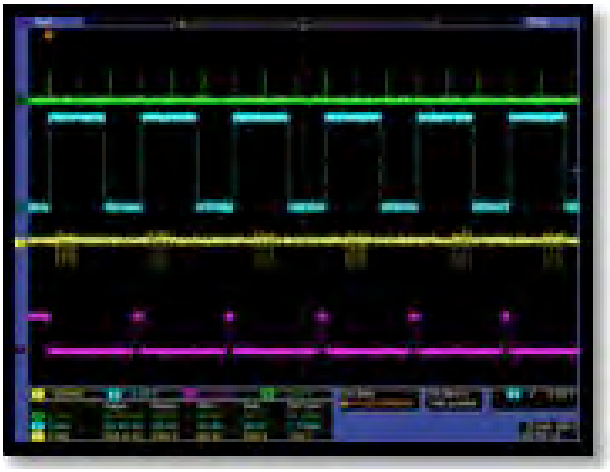
Burst per Exposure

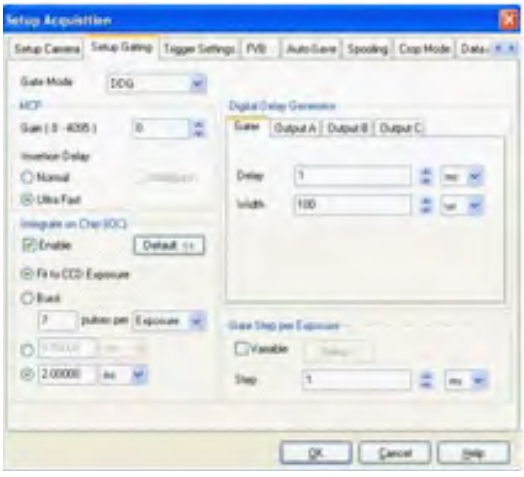
External Trigger

Fire

Gate Monitor

ARM





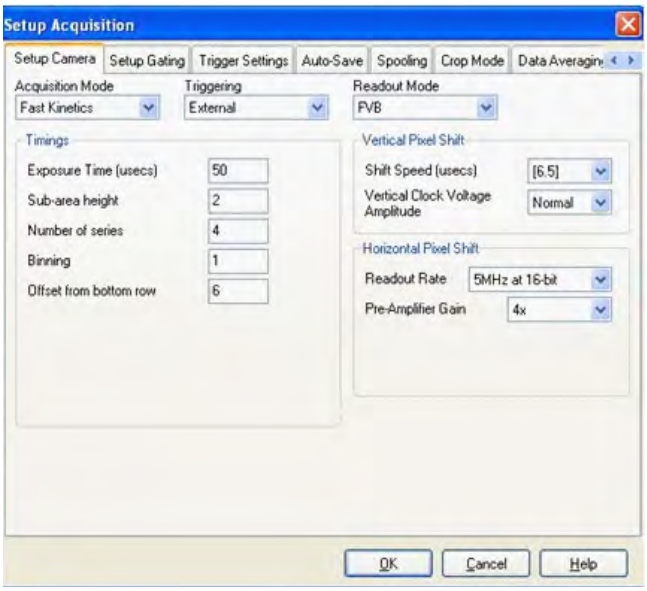
Fit to CCD Exposure

6.2.3 - Acquisition Mode: Photon Counting

Same as Acquisition Mode: Kinetic. Please refer to section 5.3.1.6 to set up the appropriate counting thresholds.

6.2.4 - Acquisition Mode: Fast Kinetics

Allows the user to acquire a short kinetics series with a rapid cycle time. The image is captured on a sub section of the sensor array, with the remainder of the array being used as a storage area until the data series is readout. The user can specify the exposure time for each frame within the series (in seconds), the size of the sub-section capturing the image (in rows) and the binning pattern. The number in the series can also be entered but is limited to a maximum value equal to the number of rows in the sensor array divided by the number of rows specified in the sub section.



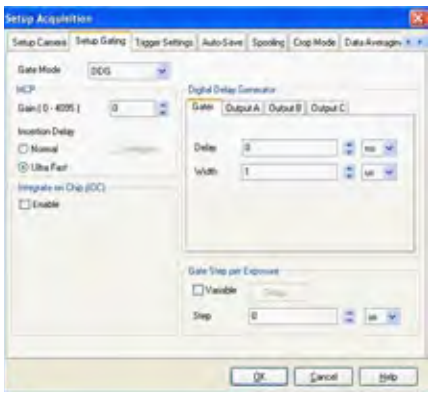
6.2.4.1 - Standard Operation (IOC Disabled and Gate Step Disabled)

Description

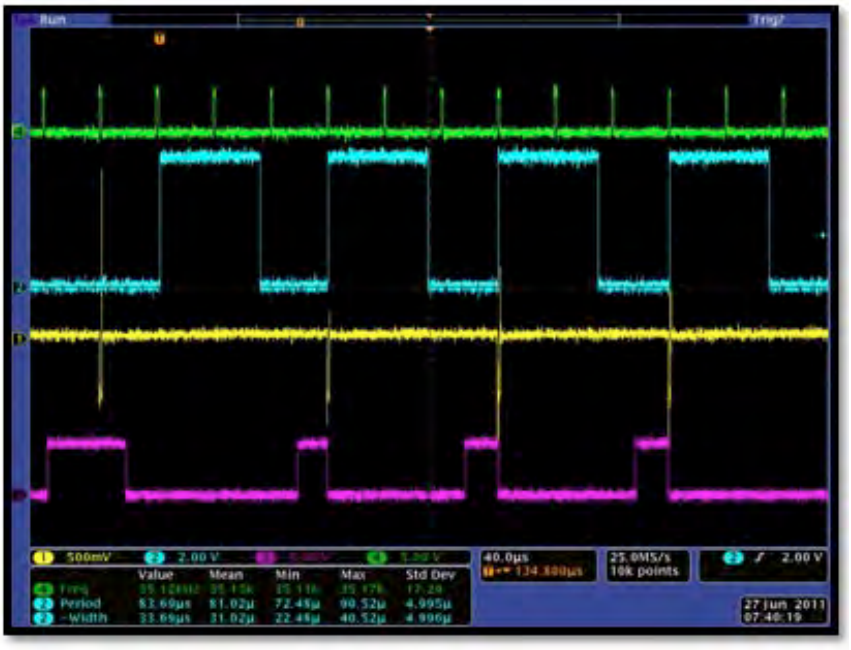
The external trigger generates one gate pulse per exposure. A gate delay is applied that is the same for each exposure in the series.

Setup

IOC disabled, gate step disabled, output A/B/C disabled.



Waveforms



6.2.4.2 - Integrate on Chip (IOC) Enabled

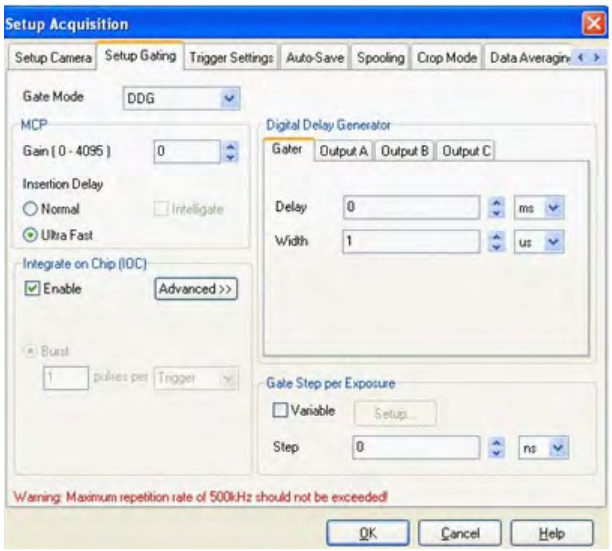
6.2.4.2.1 - Default: One Pulse per Trigger

Description

Several gate pulses can be generated within an exposure. A gate delay is applied that is the same per every trigger within an exposure. Every external trigger within an exposure can generate only one gate pulse.

Setup

IOC enabled, output A/B/C disabled.

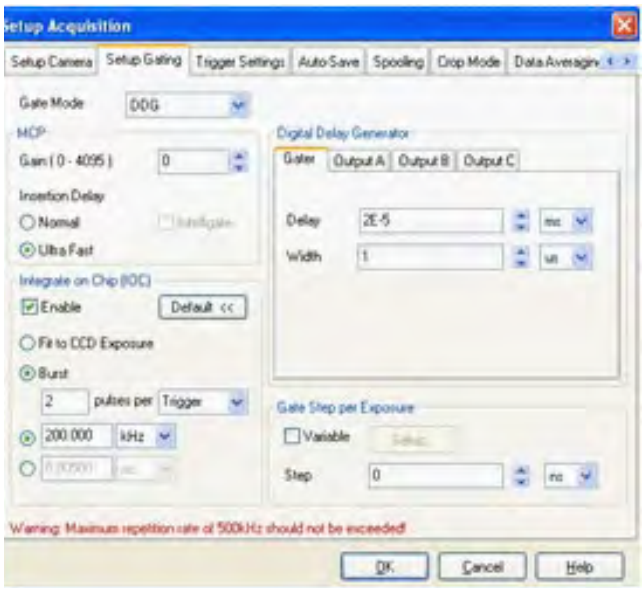


Waveforms

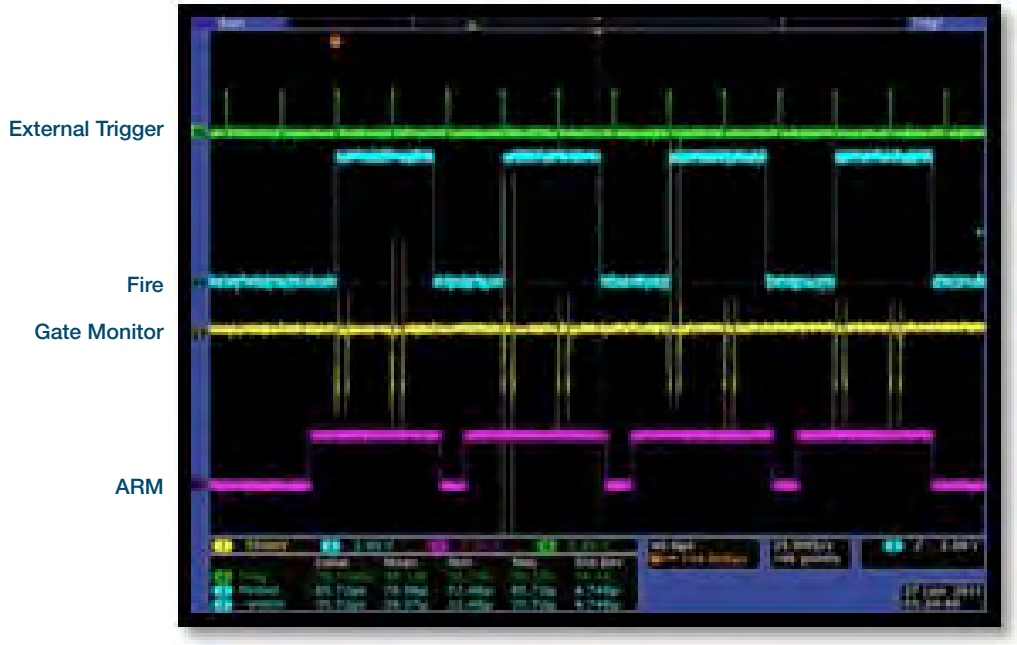
6.2.4.2.2 - Advanced: Burst pulses per trigger

Description

The user can select for multiple pulses per trigger. The external trigger generates the first pulse, subsequent pulses are generated internally by a user defined period/frequency.



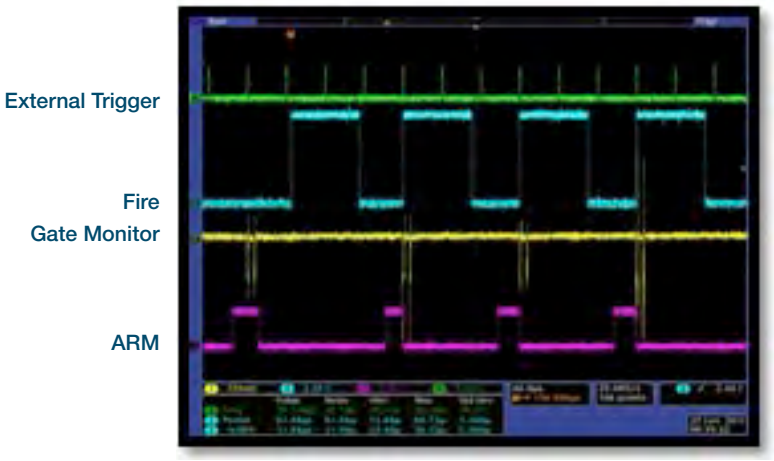
Waveforms



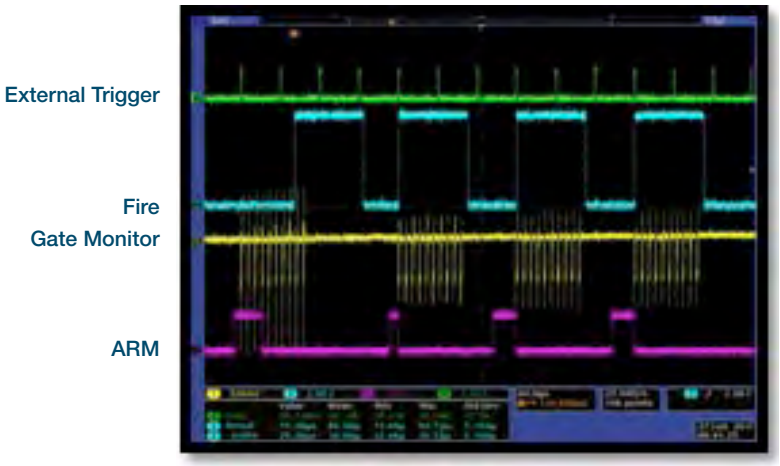
6.2.4.2.3 - Advanced: Burst/Fit Pulses per Exposure

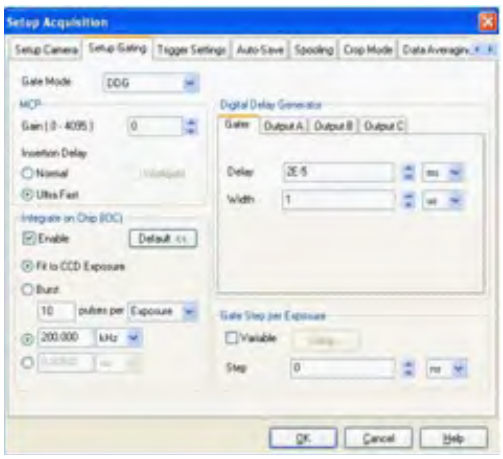
Description

Several gate pulses are generated within an exposure. A gate delay is applied that is the same for each exposure in the series. For each exposure, the external trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period. The maximum number of pulses is applied that can fit into the exposure or the user defines the number of pulses per exposure. Any subsequent triggers that arrive during the exposure are ignored.



Burst per Exposure





Fit to CCD Exposure

6.2.4.3 - Gate Step Enabled

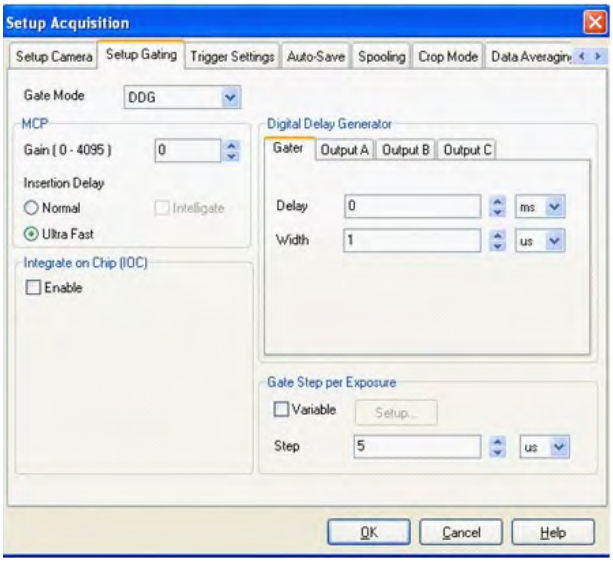
Description

The external trigger generates one gate pulse per exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value.

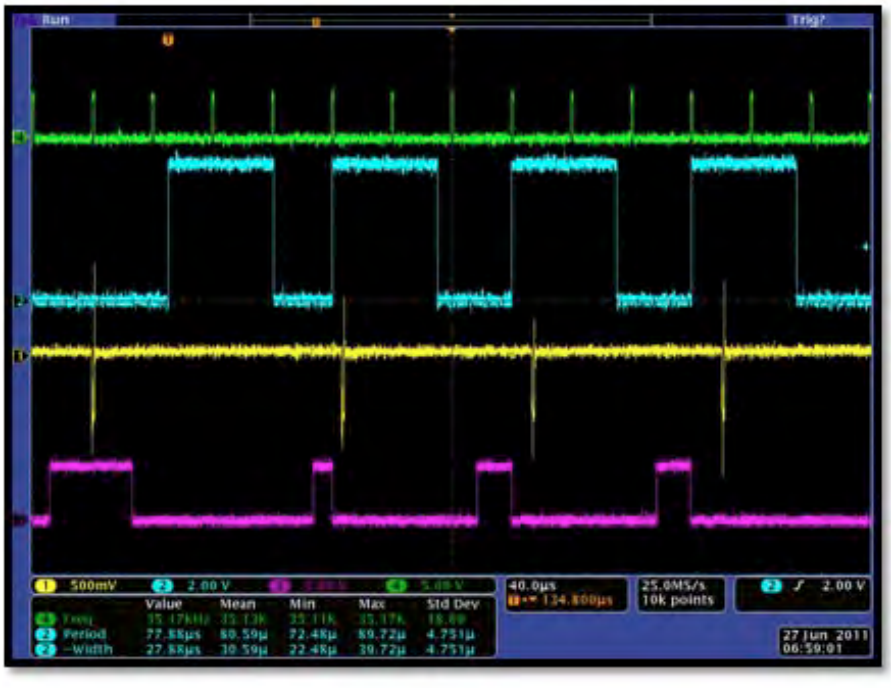
The external trigger rate can not exceed 15 kHz.

Setup

Gate step, output A/B/C disabled.



Waveforms



6.2.4.4 - IOC and Gate Step Enabled

6.2.4.4.1 - Default: One Pulse per Trigger

This mode is not supported with fast kinetics. However IOC and gate step is available in internal trigger mode.

6.2.4.4.2 - Advanced: Burst Pulses per Trigger

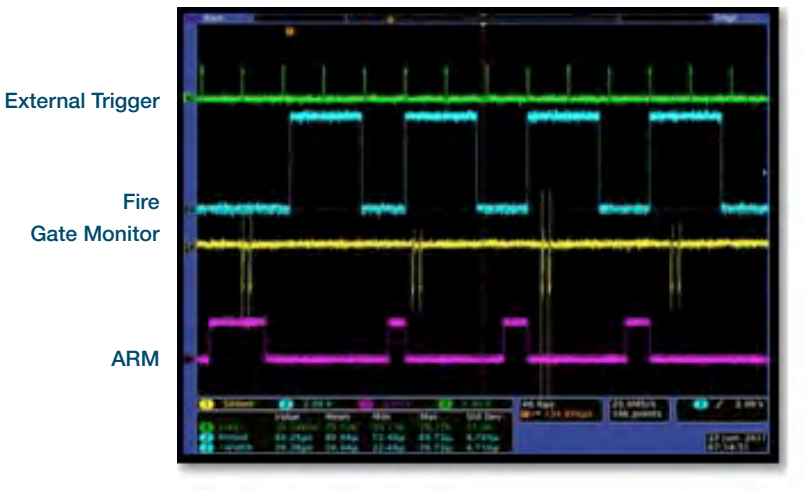
This mode is not supported with fast kinetics. However IOC and gate step is available in internal trigger mode.

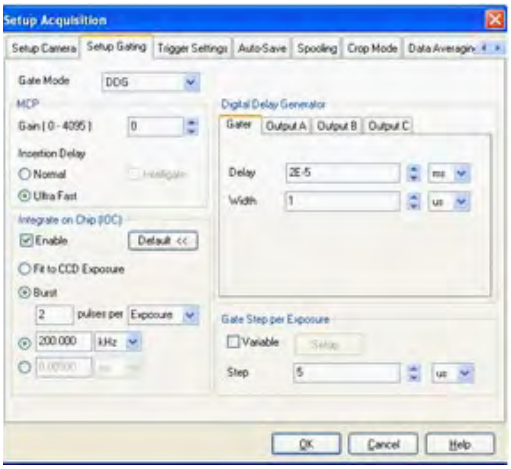
6.2.4.4.3 - Advanced: Burst/Fit Pulses per Exposure

Description

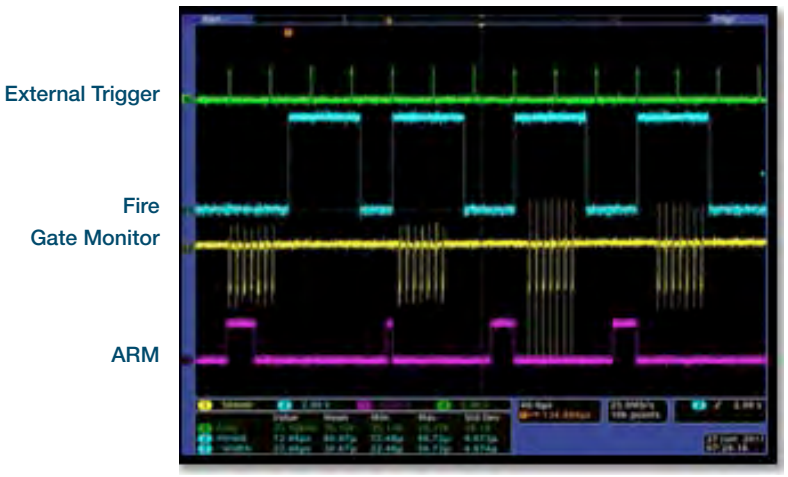
Several gate pulses are generated within an exposure. For every successive exposure in the series, the gate delay applied is incremented by the gate step value. For each exposure, the external trigger generates the first gate pulse, subsequent gate pulses are generated internally via a user defined frequency or period, or the user defines the number of pulses per exposure. The maximum number of pulses is applied that can fit into the exposure, given the final gate delay in the series. Any subsequent triggers that arrive during the exposure are ignored.

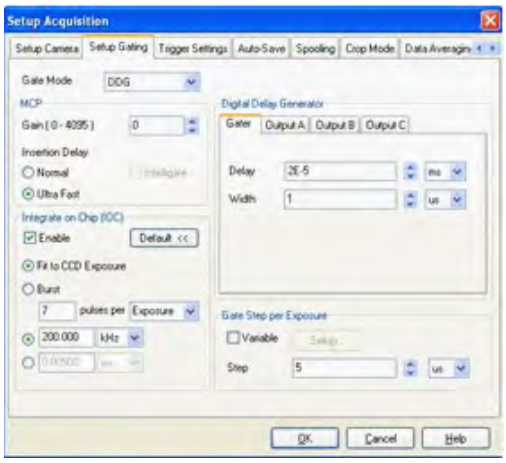
The external trigger rate cannot exceed 15 kHz.





Burst per Exposure





Fit to CCD Exposure

APPENDIX

A1 - DECLARATION OF CONFORMITY

Belfast Office
Corporate Headquarters

7 Millennium Way
Springvale Business Park
Belfast BT12 7AL
Northern Ireland

Tel: +44 (28) 9023 7126
Fax: +44 (28) 9031 0792
Web: www.andor.com

CE

Description of Equipment

The following product is manufactured in the United Kingdom by Andor Technology plc:

USB iStar ICCD (Intensified Charge Coupled Device) Camera (DH340T)

EU Declaration of Conformity (EMC)

Andor Technology plc hereby declares under its sole responsibility that the aforementioned product meets the requirements of **EU EMC Directive 2004/108/EC** by means of conformity to the following harmonised standards:

- EN 61326-1:2006 Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements [Class A]
- EN 55011:2007 Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement [Class A]
- EN 61000-4-2:2009 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Electrostatic discharge immunity test [Criterion A]
- EN 61000-4-3:2006 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test [Criterion A]
- EN 61000-4-4:2004 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Electrical fast transient/burst immunity test [Criterion A]
- EN 61000-4-5:2006 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Surge immunity test [Criterion A]
- EN 61000-4-6:2009 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields [Criterion A]
- EN 61000-4-11:2004 Electromagnetic compatibility (EMC) - Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests [Criterion A]

Offices in
North America
Japan
China

EU Declaration of Conformity (LVD)

Andor Technology plc hereby declares under its sole responsibility that the aforementioned product meets the requirements of **EU Low Voltage Directive 2006/95/EC** by means of conformity to the following harmonised standards:

- EN 61010-1:2001 Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements *(identical to IEC 61010-1)*

Additional EMC Standards

This product also complies with the following:

- FCC Part 15 Subparts A and B Code of Federal Regulations
  Title 47: Telecommunications - Part 15: Radiofrequency Devices [Class A]
- EN 61000-3-3:2008 Electromagnetic compatibility (EMC) - Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
- DD ENV 50204:1996 Radiated electromagnetic field from digital radio telephones - Immunity test [Criterion B]

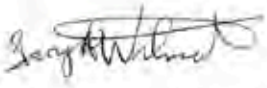
Additional Safety Standards

This product also complies with the following:

- All national deviations listed under the IEC CB Scheme for IEC 61010-1 for those countries that require them (currently Australia, Canada, Japan, Korea, Switzerland and USA) including the following, amongst others:
  - UL 61010-1 Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (2nd Edition 2004)
  - CAN/ CSA-C22.2 No. 61010-1-04 Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements (2nd Edition)

CE Mark

CE Mark first applied to this product in the year 2011



Gary Wilmot

Director of Engineering

18th February 2011

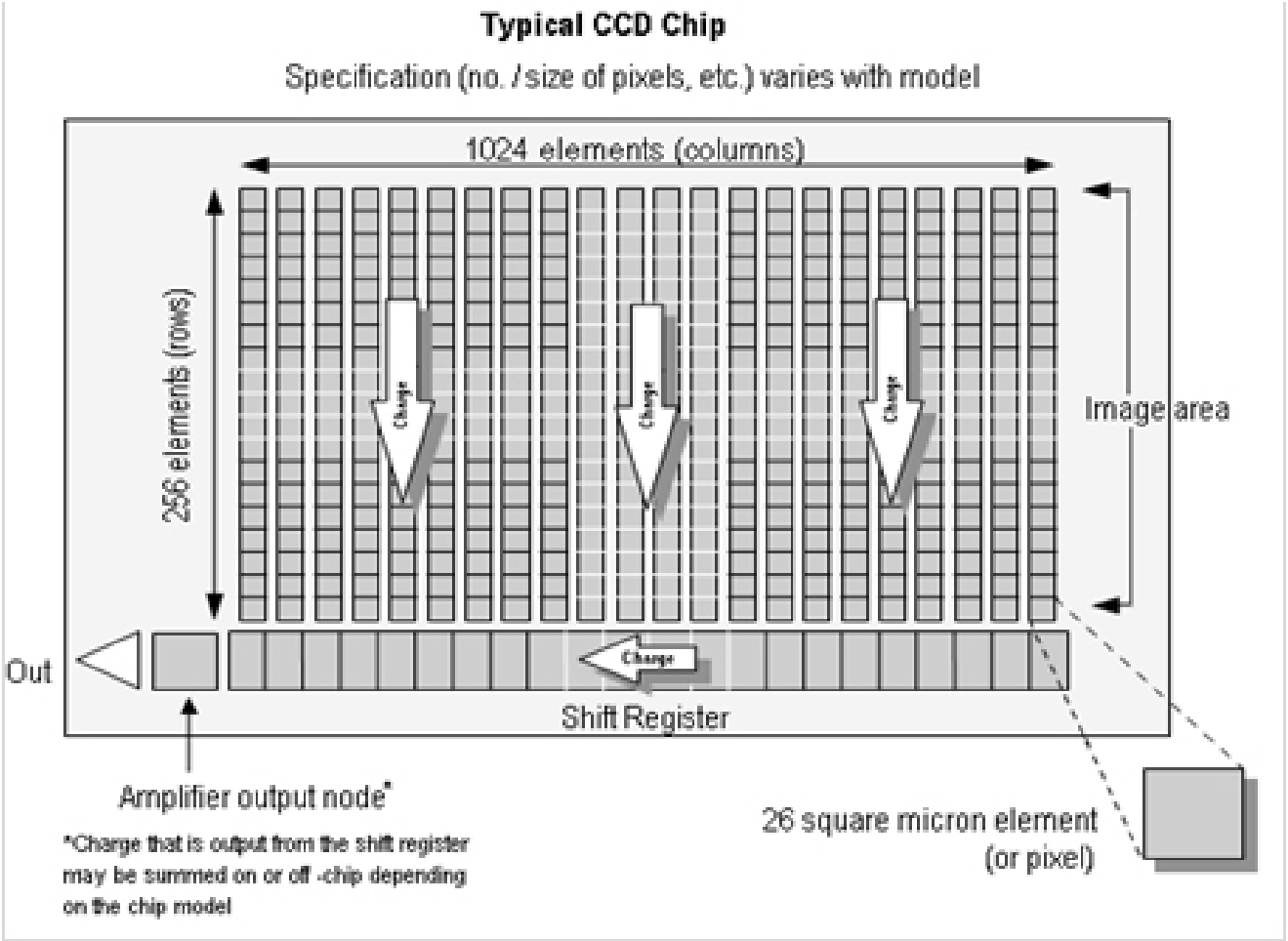
A2 - GLOSSARY

The glossary that follows will help familiarize the users and potential users with the design philosophy and some of the key terminology associated with the new iStar.

CCD

Intensified **C**harge **C**oupled **D**evices **(ICCD)**, comprise of a **G**ated **I**mage Intensifie**r** and a **CCD-Sensor.** A Charge Coupled Device (CCD) is a silicon-based semiconductor chip bearing a two-dimensional matrix of photo-sensors, or pixels. This matrix is usually referred to as the image area. The pixels are often described as being arranged in rows and columns (rows running horizontally, columns vertically).

The CCD in your detector is a scientific slow scan device (in contrast to the fast scan CCD used in video cameras to capture moving images). An example of a typical layout is shown here:



The shift register runs below and parallel to the light collecting rows. It has the same number of pixels as a light-collecting row, but is itself masked, so that no light can fall on it. When light falls on an element, electrons (photoelectrons) are produced and (in normal operation), these electrons are confined to their respective elements. Thus, if an image (or any light pattern) is projected on to the array, a corresponding charge pattern will be produced.

To capture the image pattern into computer memory, the charge pattern must be transferred off the chip, and this is accomplished by making use of a series of horizontal (i.e. parallel to the rows/shift register) transparent electrodes that cover the array. By suitable ‘clocking’, these electrodes can be used to shift (transfer) the entire charge pattern, one row at a time, down into the shift register. The shift register also has a series of electrodes (which are vertical, i.e. parallel to the columns) which are used to transfer the charge packets, one element at a time, into the output node of the “on-chip” amplifier. The output of the amplifier feeds the analog-to-digital (A/D) converter, which in turn converts each charge packet into a 16-bit binary number.

ACCUMULATION

Accumulation is the process by which data that have been acquired from a number of similar **scans** are added together in computer memory. This results in improved **signal to noise ratio**.

ACQUISITION

An **Acquisition** is taken to be the complete data capture process that is executed whenever you click T**ake Signal, Take Background, or Take Reference** on the **Acquisition Menu** or whenever you click the button

A/D CONVERSION

Charge from the **CCD** is initially read as an analog signal, ranging from zero to the saturation value. **A/D conversion** changes the analog signal to a binary number which can then be manipulated by the computer.

BACKGROUND

Background is a data **acquisition** made in darkness. It is made up of fixed pattern **noise**, and any signal due to **dark current**.

BINNING

Binning is a process that allows charge from two or more pixels to be combined on the CCD-sensor prior to **readout** (see section 5.3.3).

Summing charge on the CCD and doing a single readout results in better noise performance than reading out several pixels and then summing them in the computer memory. This is because each act of reading out contributes to noise (see **NOISE** later in this section).

The two main variants of the binning process are:

1. Vertical binning
2. Horizontal binning

In addition there are several binning patterns that tailors the main binning variants to typical application usage.

COUNTS

Counts refer to the digitization by the A/D conversion and are the basic unit in which data are displayed and processed. Depending on the particular version of the detection device, one count may, for example, be equated with a charge of 10 photoelectrons on a pixel of the CCD.

DARK SIGNAL

Dark signal, a charge usually expressed as a number of electrons, is produced by the flow of **dark current** during the **exposure time.** All CCD produce a dark current, an actual current that is measurable in (typically tenths of) milliamps per pixel. The dark signal adds to your measured signal level, and increases the amount of **noise** in the measured signal. Since the dark signal varies with temperature, it can cause **background** values to increase over time. It also sets a limit on the useful exposure time.

Reducing the temperature of the CCD reduces dark signal (typically, for every 7ºC that temperature falls, dark signal halves). CCD readout noise is low, and so as not to compromise this by shot noise from the dark signal, it is important to cool the detector to reduce the dark signal. If you are using an exposure time of less than a few seconds, cooling the detector below 0ºC will generally remove most of the shot noise caused by dark signal.

DETECTION LIMIT

The **Detection Limit** is a measure of the smallest signal that can be detected in a single readout. The smallest signal is defined as the **signal** whose level is equal to the **noise** accompanying that signal, i.e. a signal to **noise ratio (S/N) o**f unity.

Sources of noise are:

- Shot noise of the signal itself
- Shot noise of any dark signal
- Readout noise

If the signal is small, we can ignore its shot noise.

EXPOSURE TIME

The **Exposure Time** is the period during which the CCD collects light prior to readout. In the Andor system it is marked by a pulse on the **Fire** output **(Pin 11**) of the **Controller Card'**s auxiliary connector

KEEP CLEANS

The CCD-sensor is continually being scanned to keep it in a **"ready state"**. Scanning involves moving charge from the CCD-sensor into the shift register and then emptying the shift register. If the scan is being used simply to clean the CCD-sensor (i.e. it is a keep-clean scan), the charge that is emptied from the shift register is not stored in memory and is, in effect, discarded.

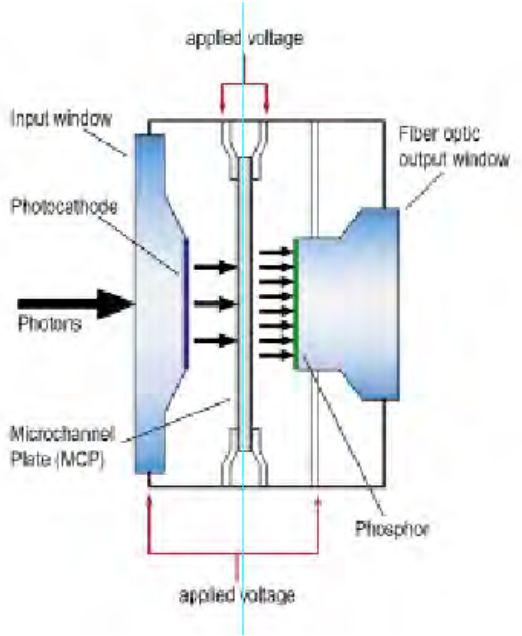
While running an Accumulate or Kinetic acquisition, use the Keep Clean Dialogue box to enter a minimum number of Keep Cleans between each scan in the series.

IMAGE INTENSIFIERS

An Image intensifier is an evacuated, proximity-focus device that amplifies the intensity of an incoming signal. The device is small, typically 1-2 inches in diameter and 1 inch thick. As well as amplifying incoming signal, an image intensifier can rapidly be switched on and off, allowing it to be used as a very fast optical shutter in the nanosecond time regime. The image intensifier used in the system can either be of 2nd generation ('Gen 2') or 3rd generation ('Gen 3').

There are three major elements in an image intensifier :

- The photocathode
- The Micro-Channel Plate (MCP)
- The output Phosphor screen



PHOTOCATHODES AND WINDOWS

The photocathode is coated on the inside surface of an input window, typically made of silica, MgF2, Borosilicate glass of fibre-optic plate. The input window typically set the lower detection limit, while the photocathode set the upper detection wavelength.

When an incoming photon strikes the photocathode, a photoelectron may be emitted, depending on the QE of the photocathode. This photoelectron is drawn across a small gap towards the MCP by an electric field.

'Gen 2' refers to multi-alkali based photocathodes that present a wide wavelength coverage from UV up to ~ 900 nm, with moderate peak QE up to ~25-30%. The lower detection limited is set by the photocathode substrate, typically Silica of Magnesium Fluoride (MgF2). These photocathode are quite resistive, and require a metallic underlay (full or grid-type) to achieve nanosecond gating times (at the expense of a few percent QE).

'Gen 3' refers to Gallium-Arsenide (GaAs) – based photocathodes. These are typically deposited on glass - which set the lowest detection limit at ~ 350 nm, and are sensitive up to ~900 nm. They present peak QE up to 50%.

Note: Please refer to sections 2.5 and 2.6 for further details on image intensifiers options.

Gating - The voltage on the photocathode in relation to the input of the MCP can be rapidly toggled between 2 levels. If the voltage of the photocathode is made positive relative to the input of the MCP, then the photoelectrons will not have sufficient energy to leave the photocathode and the image intensifier will effectively be OFF.
By switching the voltage the intensifier can be turned ON and OFF. This process is referred to as "Gating". Gating periods in the nanosecond scale (billionth of a second) can be readily achieved, making the image intensifier, one of the fastest optical shutters available.

INTERNAL REFLECTION IN THE INPUT WINDOW

Data acquired from ICCDs with a 25 mm intensifier tube may exhibit an artifact due to light that has entered the camera obliquely and has been internally reflected in the input window. The effect is generally not significant, but a brief explanation may be appropriate nonetheless.

At the center of the photocathode the internally reflected rays may coincide with each other and with light falling on the photocathode directly. The result is a signal around 5% higher than average at the center of the photocathode. The phenomenon appears as a slight peak in the middle of a 2D trace, or as a slight cone in the middle of an image.

The aperture in the faceplate is left deliberately large to fully accommodate the light cone from lenses and spectrographs. If an aperture of 25-26 mm diameter is placed in front of the input window, the range of angles at which light can enter is reduced and the peak or cone effect disappears. There may then, however, be a vignette effect as light from the outside of the light cone emerging from lenses or spectrographs is blocked.

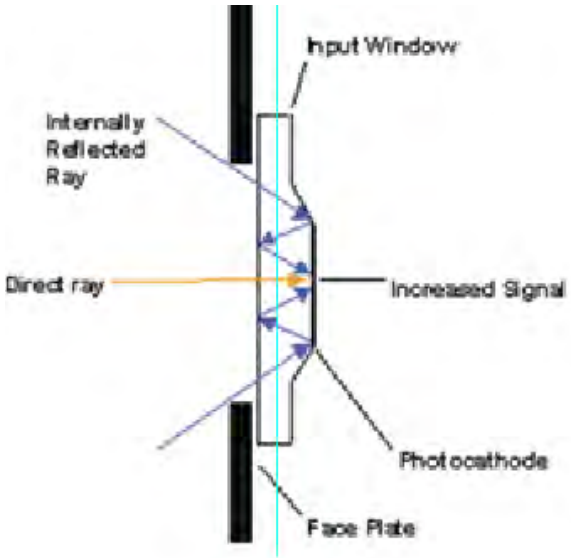


Figure X: Internal reflection in the Intensifier input window.

MICRO CHANNEL PLATE (MCP)

The MCP is a thin disk (~1mm) of honeycomb glass. Each of the ~10 µm honeycomb channels is coated with a resistive material.

The MCP plate has a high potential across it (500V to 1kV) so that an incoming photoelectron will cascade down the channel, producing secondary electrons by impact ionization. Typical gain for single stage MCP can be as high as 104 – gain can be adjusted by varying the voltage potential across the MCP. This is typically achieved through a software-controlled DAC in research-grade Intensified CCDs.

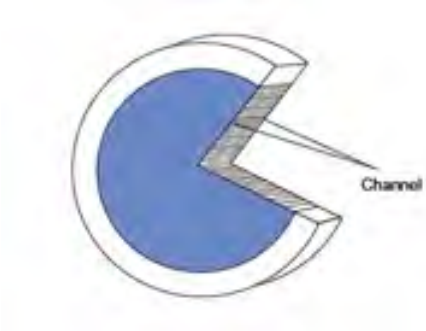


Figure X: Microchannel Plate (MCP)

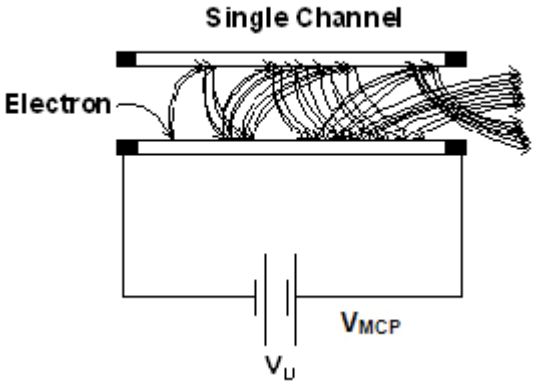


Figure X: Amplification in one channel

PHOSPHORS

The function of the Phosphor on the inside of the intensifier's fiber optic exit window is to convert the incident electron pattern into a visible light pattern that can be detected by the CCD. For best efficiency, it is important that the emission of the phosphor is matched to the response of the CCD.

PHOSPHOR TYPE	COLOR	EMISSION PEAK (NM)	DECAY TIME (TO 10%)	COMPOSITION	RELATIVE LIGHT OUTPUT
P46	Yellow/Green	530	200 ns	$Y_3Al_5O_{12}$:Ce	10
P43	Yellow/Green	545	2 ms	Gd_2O_2S:Tb	100

Our systems use either **P46** or **P43** Phosphor as standard (details are shown in the table above). P46 is used for applications requiring fast scan rates (> 100 Hz). If these speeds are not required then the more efficient P43 is preferable. P43 is used in preference to the more commonly used P20 because of superior linearity. See the specification supplied with your system for more details.

COUPLING TO THE SENSOR

The **output** of the image intensifier is coupled to a **sensor** via either a lens - with possible vignetting and lower throughput, or a fibre-optic plate for low distortion and maximum throughput. The high efficiency fibre optic coupling in the New iStar is important because it means that the image intensifier can be operated at lower gains, which results in better dynamic range and linearity. This is why **ICCD**s have replaced **I**ntensified **P**hotodiode **A**rrays (**IPDAs**) as the detector of choice.

Fibre-optics plate can be tapered to best match the image intensifier aperture size (typically Ø18 or 25 mm for Intensified CCDs) to the CCD size.

NOISE

Noise is a complex topic, a full exploration of which is beyond the scope of this glossary. Noise may, however, be broken down into two broad categories:

1. Pixel Noise
2. Fixed Pattern Noise

PIXEL NOISE

Let us first attempt to define pixel noise. Assume that a light signal is falling on a pixel of the CCD. If the charge on the pixel is read, and the read process is repeated many times, the noise may be taken as the variation in the values read. The **Root Mean Square (r.m.s.)** of these variations is often used to express a value for noise. As a rule of thumb, the r.m.s. is four to six times smaller than the peak to peak variations in the count values read from the pixel. Pixel noise has three main constituents:

- Readout noise
- Shot noise from the dark signal
- Shot noise from the light signal itself

Shot noise cannot be removed because it is due a known noise factor derived from these signals. Most simply defined, shot noise is the square root of the signal (or dark signal) measured in electrons.

READOUT NOISE

Readout noise is due to the amplifier and electronics: it is independent of dark signal and signal levels; it is only very slightly dependent on temperature; and it is present on every read, as a result of which it sets a limit on the best achievable noise performance.

- Shot noise is dependent on the dark signal. The dark signal is itself dependent on the exposure time and is very dependent on the temperature.
- Shot noise from the signal is additionally dependent on the signal level itself. If either the signal or the dark signal falls to zero, their respective shot noise also falls to zero.

The total pixel noise is not, however, simply the sum of the three main noise components (readout noise, shot noise from the dark signal, and shot noise from the signal). Rather, the Root Sum Square (r.s.s.) gives a reasonable approximation - thus:

total = sqrt (readnoise² + darkshot² + sigshot²)

where:

- **total** is the pixel noise
- **readnoise** is the readout noise
- **darkshot** is the shot noise of the dark signal
- **sigshot** is the shot noise of the signal

Fixed **P**attern **N**oise **(FPN**) consists of the differences in count values read out from individual pixels, even if no light is falling on the detector. These differences remain constant from read to read. The differences are due in part to a variation in the dark signal produced by each pixel, and in part to small irregularities that arise during the fabrication of the CCD. Since fixed pattern noise is partly due to dark signal, it will change if the temperature changes, but because it is fixed, it can be completely removed from a measurement by background subtraction.

QUANTUM EFFICIENCY/SPECTRAL RESPONSE

The glossary refers to signals as a number of electrons. More strictly speaking these are “photoelectrons”, created when a photon is absorbed. When a UV or visible photon is absorbed by the detector it can at best produce only one photoelectron. Photons of different wavelengths have different probabilities of producing a photoelectron and this probability is usually expressed as **Q**uantum **E**fficiency **(QE**) or spectral response.

QE is a percentage measure of the probability of a single photon producing a photoelectron, while spectral response is the number of electrons that will be produced per unit photon energy. Many factors contribute to the QE of a CCD, but the most significant factor is the absorption coefficient of the silicon that serves as the bulk material of the device.

READOUT

Readout is the process by which data are taken from the pixels of the **CCD** and stored in computer memory. The pixels, which are arranged in a single row, are read out individually in sequence. Readout involves amplifying the charge on each pixel into a voltage, performing an **A/D conversion**, and storing the data in computer memory. The time taken to perform this operation is known as the **Read Time.**

SATURATION

Saturation is the largest signal a CCD can measure. A signal is measured in terms of the amount of charge that has built up in the individual pixels on the CCD-sensor. A number of factors determine the maximum amount of charge that the CCD can handle.

Each **pixel** is ultimately limited in the amount of charge it can hold (its "well depth"), in other words, is finite. This maximum charge, or well depth, is generally quoted in electrons. The well depth of a single pixel in the CCD detector is typically in the order of 300,000 electrons, but is ultimately dependant on the sensor.

SCAN TYPES: KEEP CLEAN & ACQUIRED

The CCD is continually being **"scanned"** to keep it maintained in a **"ready state".** If the **Scan** is being used simply to "clean" the CCD (i.e. it is a **keep-clean scan**), the charge from the CCD is discarded.

In an **acquired scan**, however, the charge undergoes A/D conversion and is acquired into computer memory so that it can be used for subsequent processing and display: it is "read out" (see **Readout** previously). In this **User's Guide** "scan" generally refers to an acquired scan - unless the context specifically indicates otherwise.

SHIFT REGISTER

The **Shift Register** usually consists of a single row of elements (or **pixels**) running parallel to and below the bottom row of light-gathering pixels (the image area) on the CCD-sensor. The shift register is protected from light by an aluminum mask. The elements in the shift register have a greater capacity to store charge (a greater '**well depth**') than the other pixels on the CCD-sensor.

SHOT NOISE

Shot Noise is due to basic physical laws and cannot be removed. Any signal, whether it be a dark signal or a light signal, will have shot noise associated with it. Most simply defined:

- If the signal or **dark signal = N electrons,** the **shot noise** is the square root of N.

You can do nothing about the shot noise of your signal, but by choosing minimum exposures and operating the CCD at suitably low temperatures, the dark signal, and hence the noise from the dark signal, can be reduced.

SIGNAL TO NOISE RATIO

The **Signal to Noise Ratio (S/N)** is the ratio between a given signal and the **noise** associated with that signal. Noise has a fixed component, and a variable component **(shot noise**) which is the square root of the signal. Thus, the Signal to Noise Ratio usually increases (improves) as the signal increases.

The maximum Signal to Noise Ratio is the ratio between the maximum signal (i.e. the **saturation** level) and the noise associated with that signal. At near saturation levels the dominant source of noise is the shot noise of the signal.

A2 - TERMS & CONDITIONS

1. In these Conditions:

'**BUYER'** means the person who accepts a quotation of the Seller for the sale of the Goods or whose order for the Goods is accepted by the Seller.

'**GOODS**' means the goods (including any instalment of the goods or any parts for them) which the Seller is to supply in accordance with these Conditions.

'**SELLER**' means Andor Technology plc.

'CONDITIONS' means the standard terms and conditions of sale set out in this document and (unless the context otherwise requires) includes any special terms and conditions agreed in writing between the Buyer and Seller.

'**CONTRACT**' means the contract for the purchase and sale of the Goods.

'**WRITING**' includes telex, cable, facsimile transmission and comparable means of communication.

2. Any reference in these Conditions to any provision of a statute shall be construed as a reference to that provision as amended, re-enacted or extended at the relevant time.

3. The headings in these Conditions are for convenience only and shall not affect their interpretation.

A3 - STANDARD WARRANTY AND WARRANTY SERVICES

1.1 Introduction

1.1.1 This document describes the general Andor Standard Warranty policy and procedures as it relates to service obtained by a Customer under warranty. It does not replace or supersede any Product or Customer specific Warranty terms and conditions.

1.1.2 Warranty is a guarantee of quality of supplied goods (Software & Hardware). It is an obligation to rectify or replace product defects during an agreed period of time.

1.2 Standard Warranty Policy

1.2.1 Andor's Limited Standard Warranty Policy on Hardware warrants all new products to be free from defects in materials and workmanship for 12 months from the date of dispatch. (Exceptions to the standard hardware warranty offer exist and are shown in 1.2.2, 1.2.3 below). Within this period, Andor will, at its sole option, repair or replace any components which fail in normal use. Such repairs or replacements will be made at no charge to the Customer for parts or labour; however, the Customer shall be responsible for any transportation and insurance costs from the Customer premises to the Andor designated point of return. Andor shall be responsible for transportation and insurance costs related to returning the repaired or replacement unit to the Customer. The customer shall be responsible for any import duties, taxes and customs clearance fees associated with the return of the unit. This warranty does not cover failures due to abuse, misuse, accident, or unauthorized alterations or repairs. Andor assumes no responsibility for special, incidental, punitive, or consequential damages, or loss of use.

1.2.2 The following hardware components have warranties greater than 12 months:

ICCD: Andor provides a 2 year warranty for its ICCD products. Any damage caused by laser burn, bleaching of the photocathode (brought about by over illumination of the cathode) or ion damage of the cathode (brought about by excessive numbers of photoelectrons in the Multichannel plate) will not be covered by the warranty.

1.2.3 The following products and parts have specific warranty limitations:

X-RAY Cameras: Andor's standard warranty terms apply to x-ray cameras except for the sensor and other exposed parts, which are not covered in those models a) where the sensor is openly exposed (typically DO/DX models) and/or b) where the sensor is used for the direct detection of x-ray photons.

Sensor: Andor does not warrant sensors to be completely free from defects.

Items considered as consumables are not covered under this warranty, including but not limited to the following items: cables, fibre optics, filters.

Third party products not manufactured by Andor are not covered under this warranty. The customer will only be entitled to the benefit of any such warranty or guarantee as is given by the manufacturer to Andor unless specifically agreed in writing by both parties.

1.2.4 Andor guaranties that the supplied Software substantially conforms to published specifications - original license. Andor does not warrant software to be error free or that Customers will be able to operate software without problems or interruptions. The standard software warranty period is 12 months from dispatch.

1.2.5 During Warranty, customers have access to Andor support to report product defects only. Warranty does not include training or consultancy services.

1.2.6 The Warranty period is deemed to start at the date of dispatch from Andor's manufacturing facility.

1.2.7 Customers must notify the Andor customer service centre within 30 days of taking delivery of a product or part they believe to be defective. Andor will refund all fees associated with the return of any product that has been reported as defective within 30 days of delivery.

1.2.8 Failure to pay invoices when due may result in the interruption and/or cancellation of the standard warranty.

1.2.9 Andor warrants the replacement or repaired parts/components to be free from defects in materials and workmanship for twelve months from the date of dispatch or for the reminder of the warranty period, whichever is longer.

1.2.10 For products returned under warranty Andor will extend the complete product warranty by 30 days.

Hardware and Software WARRANTY SERVICE

1.3 Service Description

1.3.1 The Andor Repair service provides a repair and return service for defective products supplied by Andor under a supply contract. Using this service the original, defective part sent in by the Customer will be, where possible, returned after repair or will be replaced. Any warranty obligation contained in an Andor supply contract will be carried out in accordance with this Repair Service.

1.3.2 In order to be eligible for warranty repair or replacement, the equipment must be suffering a defect which meets the criteria set out in the supply contract and must be within its specified warranty period. Services such as upgrades to Hardware and Software are excluded from the scope of this service description and should be ordered separately.

1.4 Access to Service

1.4.1 A Customer who has purchased their product via a reseller or third party and who believes they have a warranty defect should in the first instance contact a representative of their seller's product support team. Customers who have bought products directly from Andor can access the Service Desk at www.andor.com/contact_us/support_request .

1.4.2 The Customer should indicate that they are pursuing a warranty claim and specify the equipment type and the contract under which it was supplied. The Service Desk representative will then work with the Customer to establish the nature of the defect and to determine whether the reported defect is one which meets the criteria under the supply contract for warranty remediation. This process will comprise question and answer between Service Desk and Customer and the Service Desk operative may, at their sole discretion, ask the Customer to perform some basic diagnostic actions in relation to the problem item.

1.5 Hardware Remediation

1.5.1 If the issue cannot be resolved remotely and a fault has been diagnosed, a Return Materials Authorization ("RMA") number will be issued. This RMA number will be valid for 30 days from the date of issue. An RMA number must be obtained from Andor prior to the return of any material. The RMA number must appear clearly on the outside of the shipping container and on return paperwork included inside the package.

1.5.2 Following allocation of a RMA number by Andor, the Customer shall ship the PART to Andor at customer expense. The customer is responsible for return shipping and insurance costs. Any products returned without an RMA number may be refused and returned to the customer at their expense. Andor shall provide a single point of return for all products.

1.5.3 On receipt of the part at the Andor repair facility, Andor shall carry out the necessary fault diagnosis and repair and return the part to the Customer.

1.5.4 The method of shipment and choice of courier for the return will be at Andor's discretion. Delivery Duties Unpaid (DDU) Incoterms 2000. Andor does not guarantee the arrival time of the part.

1.5.5 Customer must adhere to Andor packing instructions (including anti-static precautions) when shipping the defective unit as any damage incurred during shipment to Andor will not be covered under warranty. The packing instructions can be obtained from Andor as part of the part request procedure.

1.5.6 If the part is not economically repairable then a replacement part (new or refurbished) will be supplied at Andor discretion and expense.

1.5.7 In case of replacement the replacement unit becomes the property of the Customer on an exchange basis.

1.5.8 In case of misuse the Customer will be contacted to decide the course of action. These actions may include:

- Scrapping the part
- Return of the defective unrepaired part to the Customer
- Replacement with a new or refurbished part. Andor will invoice the customer the full merchandise contracted customer price of the unit.

1.5.9 Unless elsewhere agreed between the Customer and Andor, this service does not include root cause analysis, the provision of fault reports or lead-time and performance metrics.

1.6 Software Remediation

1.6.1 During Warranty Customers have access to the Service Desk at andor.com/support to report product defects. A Customer who has purchased their product via a reseller or third party and who believes they have a software warranty defect should in the first instance contact a representative of their seller's product support team.

1.6.2 Where as a result of the process described in 1.3.2 above it is determined that the defect relates to software, a trouble ticket will be logged in respect of the software issues observed.

1.6.3 Under the warranty provisions of the supply contract we will not provide the customer with a guaranteed SLA (service level agreement) for their problem.

A4 - THE WASTE ELECTRONIC AND ELECTRICAL EQUIPMENT REGULATIONS 2006 (WEEE)

Where appropriate, Andor has labelled its electronic products with the WEEE label (crossed out wheelie bin) to alert our customers that products bearing this label should not be disposed of in a landfill or with municipal waste. If you have purchased Andor-branded electrical or electronic products in the EU after August 13, 2005, and are intending to discard these products at the end of their useful life, Andor are happy to assist.

The cost for the collection, treatment, recycling, recovery and sound environmental disposal of these goods at the end of its useful life has not been included in the price. If you require help/assistance regarding the disposal of this equipment please refer to our website, or contact our sales team at which point instructions and a quotation can be provided.

A copy of the Company's WEEE Policy can be viewed at the Company website andor.com.

TERMS AND CONDITIONS OF SALE

The terms and conditions of sale, including warranty conditions, will have been made available during the ordering process. The current version may be viewed at:

andor.com/contact_us/support_request/warranty/standard_warranty.pdf

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE)

The company's statement on the disposal of WEEE can be found in the Terms and Conditions.