



# ***PIXIS System***

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## Introduction

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### PIXIS

Thank you for purchasing a PIXIS camera system from Princeton Instruments. For over two decades Princeton Instruments has been the legendary name behind the most revolutionary spectroscopy and imaging products for cutting edge research.



PIXIS represents the most advanced camera design and utilizes years of experience and expertise in low-light detection. Whether your application involves Raman spectroscopy in the near infrared or semiconductor imaging in the ultraviolet, PIXIS has everything you need to tackle the most demanding applications.

Among the many state of the art features are its maintenance-free permanent vacuum, integrated controller, deep thermoelectric air-cooling, and compact design. Currently the platform supports several imaging and spectroscopy CCDs, including eXcelon<sup>®</sup> enabled back-illuminated spectroscopy CCDs. Please visit [www.princetoninstruments.com](http://www.princetoninstruments.com) for the current list of supported CCDs.

### eXcelon<sup>®</sup>

eXcelon is a new CCD/EMCCD sensor technology jointly developed by Princeton Instruments, e2v, and Photometrics. Spectroscopy CCDs using this technology provide three significant benefits:

- **Improved sensitivity** – improved QE over broader wavelength region compared to back-illuminated sensors,
- **Reduced etaloning** – up to 10 times lower etaloning or unwanted fringes in near infrared (NIR) region compared to standard back-illuminated CCDs,
- **Lower dark current** – similar to back-illuminated CCDs or 100 times lower than the deep depletion CCDs.

### Advanced Design

PIXIS is a fully integrated camera system. The camera contains all of the electronics necessary to read out and control the CCD device. For instance, it houses precision analog-to-digital converters (ADCs) positioned close to the CCD for lowest noise and has USB 2.0 electronics to interface with the host computer.

The easy-to-use PIXIS camera system offers all basic CCD camera functions such as region-of-interest (ROI) selection and binning --- all under software control. It also provides advanced triggered operation as well as programmable TTL output.

To utilize the full potential of the PIXIS camera system, please read the manual completely.

## Grounding and Safety

Before turning on the power supply (air-cooled system or liquid-cooled system with a CoolCUBE<sub>II</sub> circulator), the ground prong of the power cord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong, or must be properly connected to an adapter that complies with these safety requirements.

**WARNING!** If the equipment is damaged, the protective grounding could be disconnected. Do *not* use damaged equipment until its safety has been verified by authorized personnel. Disconnecting the protective earth terminal, inside or outside the apparatus, or any tampering with its operation is also prohibited.

Inspect the supplied power cord. If it is not compatible with the power socket, replace the cord with one that has suitable connectors on both ends.

**WARNING!** Replacement power cords or power plugs must have the same polarity and power rating as that of the original ones to avoid hazard due to electrical shock.

## Precautions

To prevent permanently damaging the system, please observe the following precautions:

- The CCD array is very sensitive to static electricity. Touching the CCD can destroy it. Operations requiring contact with the device can only be performed at the factory.
- If you are using high-voltage equipment (such as an arc lamp) with your camera system, be sure to turn the camera power ON LAST and turn the camera power OFF FIRST.
- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The CCD can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Do not block air vents on the camera. Preventing the free flow of air overheats the camera and may damage it.
- If the PIXIS camera system is used in a manner not specified by Princeton Instruments, the protection provided by the equipment may be impaired.

## UV Coating

**Caution** If you have a camera with a UV (Lumogen or Unichrome) coated CCD, protect it from unnecessary exposure to UV radiation. This radiation slowly bleaches the coating, reducing sensitivity.



## Cleaning

### WARNING!

Turn off all power to the equipment and secure all covers before cleaning the units. Otherwise, damage to the equipment or injury to you could occur.

### **Camera**

Although there is no periodic maintenance that *needs* to be performed on a PIXIS camera, users are advised to wipe it down with a clean damp cloth from time to time. This operation should only be done on the external surfaces and with all covers secured. In dampening the cloth, use clean water only. No soap, solvents or abrasives should be used. Not only are they not required, but they could damage the finish of the surfaces on which they are used.

### **Optical Surfaces**

As a good practice, the camera must be closed/capped off with the supplied dust cover or lens cap when not in use. Should a need to clean the optical window arise due to the accumulation of atmospheric dust, we advise that the *drag-wipe* technique be used. This involves dipping a clean cellulose lens tissue into clean anhydrous methanol, and then dragging the dampened tissue over the optical surface to be cleaned. Do not allow any other material to touch the optical surfaces.

## Repairs

Because the PIXIS camera system contains no user-serviceable parts, repairs must be performed by Princeton Instruments. Should your system need repair, contact Princeton Instruments customer support for instructions. For contact information, refer to page 126 of this manual.

Save the original packing materials and use them whenever shipping the system or system components.

## About this Manual

### **Manual Organization**

This manual provides the user with all the information needed to install a PIXIS camera and place it in operation. Topics covered include detailed description of the cameras in the PIXIS family, installation, applications, cleaning, specifications and more.

#### **Notes:**

1. "WinX" is a generic term for WinView/32, WinSpec/32, and WinXTest application software.
2. In many instances, WinX and LightField<sup>®</sup> use different terms for the same functions or parameters. Unless the topic is specifically for WinX or LightField, curly brackets { } are used to denote a LightField term or location. When the topic applies to both application programs, the WinX term will be followed by the {LightField term}: for example, when Continuous Cleans is used, it will be followed by {Clean Until Trigger}. This convention is also used when a location for setting a parameter is mentioned: for example, Exposure Time is set on the **Experiment Setup|Main** tab {**Common Acquisition Settings** expander}.

- Chapter 1, Introduction** provides an overview of the PIXIS cameras.
- Chapter 2, System Component Descriptions** provides information about the camera, interface card, cables and application software.
- Chapter 3, Installation Overview** cross-references system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.
- Chapter 4, System Setup** provides detailed directions for setting up the camera for imaging or spectroscopic applications and presents over-exposure protection considerations.
- Chapter 5, Operation** includes a step-by-step procedure for verifying system operation and discusses operational considerations associated with exposure, readout, and digitization.
- Chapter 6, Advanced Topics** discusses standard timing {Trigger Response} modes (Free Run {No Response}, External Sync {Readout Per Trigger}, and Continuous Cleans {Clean Until Trigger}), Fast and Safe modes, Logic Output control, and Kinetics mode.
- Chapter 7, Troubleshooting** provides courses of action to take if you should have problems with your system.
- Appendix A, Basic Specifications** includes camera and CoolCUBE<sub>II</sub> specifications.
- Appendix B, Outline Drawings** includes outline drawings of C-mount and Spectroscopy-mount cameras.
- Appendix C, Adapter Adjustment and Focusing Procedures** discusses focusing of an F-mount adapter and focusing of F-mount and C-mount lenses.
- Appendix D, Spectrograph Adapters** provides mounting instructions for the spectrograph adapters available for PIXIS cameras.
- Appendix E, Cross-Referencing of WinX and LightField Terms** includes two alphabetically sorted tables (WinX to LightField and LightField to WinX) that cross reference terms used in the two applications.
- Declaration of Conformity** contains the Declarations of Conformity for the Small Format PIXIS System and the Large Format PIXIS System
- Warranty & Service** contains the warranty and customer support contact information.

### **Safety Related Symbols Used in this Manual**



**Caution!** The use of this symbol on equipment indicates that one or more nearby items should not be operated without first consulting the manual. The same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.



**Warning! Risk of electric shock!** The use of this symbol on equipment indicates that one or more nearby items pose an electric shock hazard and should be regarded as potentially dangerous. This same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

# Chapter 2

## System Component Descriptions

### System Components

#### Standard Components

A typical air-cooled PIXIS system consists of the camera with a Certificate of Performance, a power supply, a USB 2.0 interface cable for your computer system, MCX to BNC adapter cables, and the user manual. A typical liquid-cooled PIXIS system consists of the camera with a Certificate of Performance, a CoolCUBE<sub>II</sub> circulator with hoses, a USB 2.0 interface cable for your computer system, MCX to BNC adapter cables, and the user manual.



Figure 1. Typical System Components

#### Optional System Components

Optional items include the WinX application software and manual, LightField<sup>®</sup> application software and manual, Scientific Imaging ToolKit<sup>™</sup> (SITK<sup>™</sup>) for LabVIEW<sup>®</sup>, internal 25 or 45 mm shutter (dependent on CCD array size), an F-mount adapter, an adjustable C- to Spectroscopy-mount kinetics adapter, and a fiber optic extender kit.

## PIXIS Camera

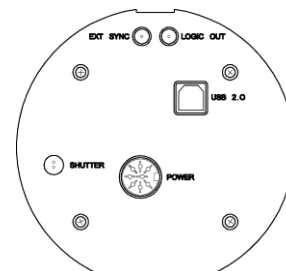
**CCD Array:** The PIXIS camera system offers both front- and back-illuminated CCDs in a variety of array sizes that allow you to precisely match the sensor to your application. Only scientific-grade devices are used in order to ensure the highest image fidelity, resolution, and acquisition flexibility required for scientific imaging. Princeton Instruments has developed exclusive CCDs with unmatched quantum efficiency and low noise to offer the utmost in sensitivity. Large full wells, square pixels, and 100% fill factors provide high dynamic range and excellent spatial resolution. Unichrome (exclusive Princeton Instruments technology) and other UV-enhancement coatings can be used to further improve the quantum efficiency of these CCDs in the ultraviolet. Your choice of CCD is already installed in the camera that you received and has been individually tested.



**Cooling:** Dark current is reduced in PIXIS camera systems through thermoelectric cooling of the CCD arrays. Cooling by this method uses a four-stage Peltier cooler in combination with circulating air or coolant. To prevent condensation and contamination from occurring, cameras cooled this way are evacuated. Due to CCD size/packaging differences, the lowest achievable temperature can vary from one PIXIS model to the next. Please refer to the specific system's data sheet for cooling performance.

### Connectors:

**USB 2.0:** Control signals and data are transmitted between the camera and the host computer via the USB port located on the rear of the camera. As of this printing, you can hot plug the PIXIS camera whenever the WinX application is not running (i.e., connect or disconnect from the camera or the host computer while the camera is powered ON). In the case of cameras built before November 1, 2005, you must exit the WinX application and turn the camera power OFF before connecting the USB cable to or disconnecting it from the camera or host computer.



**Shutter:** LEMO<sup>®</sup> connector provides the shutter drive pulses for driving a Princeton Instruments-supplied external shutter (for example, a shutter at the entrance slit of a spectrograph). Camera power must be OFF before connecting to or disconnecting from this connector.

**Note:** When there is an installed internal shutter, this connector cannot drive an external shutter.

**LOGIC OUT:** 0 to +3.3V programmable logic level output (TTL-compatible). The output of this connector can be programmed and can also be inverted via the application software. For detailed information about each output signal, please see “*LOGIC OUT Control*” (page 74).

**EXT SYNC:** 0-+3.3V logic level input (TTL-compatible) that has a 10 k $\Omega$  pullup resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) edge triggering can be selected.

**Power:** 12 VDC (6.6A max) input from power supply.

**Fan:** Air-cooled cameras contain an internal fan. Its purpose is:

- to remove heat from the Peltier device that cools the CCD array and
- to cool the electronics.

An internal Peltier device directly cools the cold finger on which the CCD is mounted. The air drawn into the camera by the internal fan through the back slots on the side panels and exhausted through the front slots on the side panels then removes the heat produced by the Peltier device. The fan is always in operation and air-cooling of both the Peltier and the internal electronics takes place continuously. The fan is designed for low-vibration and does not adversely affect the image. For the fan to function properly, free circulation must be maintained between the sides of the camera and the laboratory atmosphere.

**Coolant Ports:** Liquid-cooled cameras have internal hoses that can be connected to the CoolCUBE<sub>II</sub> circulator via the coolant ports on the side of the camera (either port can be the input). As is the case with circulating air (see above), circulating coolant removes the heat produced by the Peltier device. This means of heat removal is designed for vibration-free data acquisition. For the circulating coolant to function properly, free air circulation must be maintained between the sides of the CoolCUBE<sub>II</sub> and the laboratory atmosphere.

**WARNING!** Use only the hoses and circulator shipped with your system. Attaching any other hoses or circulator voids the warranty.

## Power Supply (Air-cooled and CoolCUBE<sub>II</sub> Liquid-cooled systems)

The receptacle on the power supply should be compatible with the line-voltage line cords in common use in the region to which the system is shipped. If the power supply receptacle is incompatible, a compatible adapter should be installed on the line cord, taking care to maintain the proper polarity to protect the equipment and assure user safety.

### Small Format PIXIS



**Maximum Power Output:** 80 W  
**Input:** 100-240 V<sub>AC</sub>, 47-63 Hz, 1.9A  
**Output:** 12 V<sub>DC</sub> at 6.6 A maximum

### Large Format PIXIS



**Maximum Power Output:** 150 W  
**Input:** 100-240 V<sub>AC</sub>, 50/60 Hz, 2A  
**Output:** 12 V<sub>DC</sub> at 12.5 A maximum

## Coolant Hoses (Liquid-cooled systems)



Quick-disconnects that mate to the PIXIS's coolant ports have been installed on one end of each hose. Refer to your coolant circulator's specifications regarding circulator-compatible hose fittings. If a Princeton Instruments CoolCUBE<sub>II</sub> circulator is ordered with the camera, hoses are supplied with appropriate connectors on both ends.

**Note:** Part numbers for the hose, PIXIS fittings, and CoolCUBE<sub>II</sub> fitting are:

- McMaster# MCM 5238K748 (3/8 ID, 5/8 OD tubing);
- CPC# MCD1004 (1/4 NPT Valved Coupling Body) and McMaster# MCM 5346K35 (barbed hose fitting adapter for 3/8" hose ID X 1/4" NPTF female pipe) at PIXIS end; and
- CPC# NS6D17006 (3/8 hose barb valved in-line coupling body) at CoolCUBE<sub>II</sub> end.

## Cables



**USB 2.0 Cable:** The standard 16.4' (5 m) cable (6050-0494) has USB connectors that interconnect the "USB 2.0" connector on the rear of the PIXIS with a USB card installed in the host computer.



**MCX to BNC Adapter Cables:** Two MCX to BNC adapter cables are provided with the PIXIS system. These mount to the EXT SYNC and the LOGIC OUT connectors on the rear of the PIXIS.

## Certificate of Performance



Each PIXIS camera has a Certificate of Performance. This certificate states that the camera system was assembled and tested according to approved Princeton Instruments procedures. It documents the camera performance data as measured during the testing of your PIXIS and lists the Sales Order, Purchase Order, and Camera Serial numbers (useful if you ever need to contact Princeton Instruments Customer Support).

## User Manuals



**PIXIS System User Manual:** This manual describes how to install and use the PIXIS system components.

**WinView/32 or WinSpec/32 User Manual:** This manual describes how to install and use the application program. A PDF version of this manual is provided on the installation CD. Additional information is available in the program's on-line help.

**LightField® User Manual:** This manual describes how to install and use the LightField application program (for 64-bit Windows Vista® and Windows® 7 operating systems). The manual is provided in PDF version on the installation CD and will be installed in the Princeton Instruments/LightField/Documents subdirectory. Acrobat 7.0 or higher is required. Additional information is available in the program's on-line help.



**Note:** You can download current versions of Princeton Instruments manuals at [ftp://ftp.princetoninstruments.com/Public/Manuals/Princeton Instruments/](ftp://ftp.princetoninstruments.com/Public/Manuals/Princeton%20Instruments/). The most current versions of Acton manuals are located at <ftp://ftp.princetoninstruments.com/Public/Manuals/Acton/>.

## Optional Components

### Application Software



**WinX:** The PIXIS camera can be operated by using either WinView/32 or WinSpec/32, Princeton Instrument's 32-bit Windows® software packages designed specifically for high-end imaging and spectroscopy, respectively. The Princeton Instruments' software provides comprehensive image/spectral capture and display functions. The package also facilitates snap-ins to permit advanced operation. Using the optional built-in macro record function, you can also create and edit your own macros to automate a variety of operations. WinView and WinSpec take full advantage of the versatility of the PIXIS camera and even enhance it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

**PVCAM®:** The standard software interface for cooled CCD cameras from Princeton Instruments. It is a library of functions that can be used to control and acquire data from the camera when a custom application is being written. For example, in the case of Windows, PVCAM is a dynamic link library (DLL). Also, it should be understood that PVCAM is solely for camera control and image acquisition, not for image processing. PVCAM places acquired images into a buffer, where they can then be manipulated using either custom written code or by extensions to other commercially available image processing packages.

**Scientific Imaging ToolKit™:** SITK™ is a collection of LabVIEW® VIs for scientific cameras and spectrographs. This third party software can be purchased from Princeton Instruments.



**LightField®:** The PIXIS can be operated using LightField, Princeton Instrument's 64-bit Windows Vista® and Windows® 7 compatible software package. LightField combines complete control over Princeton Instruments' cameras and spectrographs with easy-to-use tools for experimental setup, data acquisition and post-processing. LightField makes data integrity priority #1 via automatic saving to disk, time stamping and retention of both raw and corrected data with full experimental details saved in each file. LightField works seamlessly in multi-user facilities, remembering each user's hardware and software configurations and tailoring options and features accordingly. The optional, patent-pending IntelliCal™ package is the highest-performance wavelength calibration software available, providing up to 10X greater accuracy across the entire focal plane than competing routines.

**PICam™:** The standard 64-bit software interface for cooled CCD cameras from Princeton Instruments. PICam is an ANSI C library of camera control and data acquisition functions. Currently, the interface supports Windows Vista and Windows 7.

**Note:** PIXIS may also be operated by several other third-party software packages. Please check with the providers of the packages for compatibility and support information.





### ***Internal Shutter***

Optional 25 or 45 mm internal shutter (dependent on CCD array size). Shutters are mechanical devices with a finite lifetime, typically of the order of a million cycles, although some individual shutters may last a good deal longer. How long a shutter lasts in terms of experimental time will, of course, be strongly dependent on the operating parameters. High repetition rates and short exposure times will rapidly increase the number of shutter cycles and hasten the time when the shutter will have to be replaced.



### ***F-Mount Adapter***

An F-mount adapter (7050-0009) is available for modifying a spectroscopy-mount PIXIS with internal shutter (see Figure 68, page 105).



### ***Adjustable C- to Spectroscopy-Mount Kinetics Adapter***

An adjustable C- to Spectroscopy-mount kinetics adapter is available for modifying a C-mount PIXIS for mounting to an Acton spectrograph. The adapter allows you to move the camera vertically at the exit plane of an Acton Series spectrograph in order to align kinetics rows at the middle of the focal plane for the best spectral quality. Two versions are available: Model 7050-0104 for SP-2350 and SP-2550 spectrographs and Model 7050-0107 for SP-2150 and SP-2750 spectrographs.



### ***Fiber Optic Extender Kit***

The specially designed fiber optic data interface kit allows the computer and the USB2.0 camera head to be separated by up to 500 meters without the loss of data. The kit consists of two compact, high speed transceivers (interface modules) for completely transparent operation between the host computer and the camera. The FO kit is ideal for hazardous or high EMI environments. This optional kit supports PIXIS, Spec-10, VersArray and PI-MAX family of products as well Acton Series spectrographs with USB2.0 data interface.



### ***CoolCUBE<sub>II</sub> with PIXIS-compatible Hoses (PN 7567-0002)***

Liquid-cooled PIXIS cameras can cool to a lower temperature (typically  $-35^{\circ}\text{C}$ ) than air cooling. Instead of using a fan to remove heat, these cameras incorporate a closed loop system of circulating fluid. The CoolCUBE<sub>II</sub> circulator unit continuously pumps the 50:50 mixture of room temperature ( $23^{\circ}\text{C}$ ) water and ethylene glycol. To prevent voiding the warranty, use only the circulator and hoses shipped with your system.



# Chapter 3

## Initial System Verification

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The list and diagrams below briefly describe the sequence of actions required to install your system and prepare to gather data. Refer to the indicated references for more detailed information.

Action	Reference
1. If the system components have not already been unpacked, unpack them and inspect their carton(s) and the system components for in-transit damage.	Chapter 4 System Setup, page 21
2. Verify that all system components have been received.	Chapter 4 System Setup, page 22
3. If the components show no signs of damage, verify that the appropriate power cord has been supplied with the power supply.	Chapter 4 System Setup, page 22
4. If the application software is not already installed in the host computer, install it.	Chapter 4 System Setup, page 24 & Software manual
5. If a USB 2 interface card is not already installed in the host computer, install it. Follow the manufacturer's instructions.	
6. Depending on application, attach lens to the camera or mount the camera to a spectrograph.	Chapter 4 System Setup, page 27
7. With the power supply disconnected from the camera, connect the USB cable to the USB port at the rear of the camera and to the USB port at the computer.	
8. <b>Air-Cooled System:</b> Plug the power supply into the rear of the camera and plug the power supply into the power source. <b>Liquid-Cooled System:</b> Plug the power supply into the rear of the camera and plug the power supply into the power source. Make the hose connections to the camera. Plug the circulator into the power source. Add coolant if necessary. Turn on the circulator.	Chapter 4 System Setup, page 25
9. <b>Turn the camera ON.</b>	
10. Turn on the computer and begin running the application software.	Software manual
11. Enter the hardware setup information or load the defaults from the camera.	Chapter 5 Operation, page 27
12. Set the target array temperature.	Chapter 5 Operation, page 55
13. When the system reaches temperature lock, wait an additional 20 minutes and then begin acquiring data in focus mode.	Chapter 5 Operation, page 36 or page 39

Action	Reference
14. Adjust the focus for the best image or spectral lines. If you are using WinSpec/32, you may want to use the Focus Helper function for spectroscopy applications. If you are using LightField, you may want to use the Align Spectrometer function.	Chapter 5 Operation, page 43 or page 46

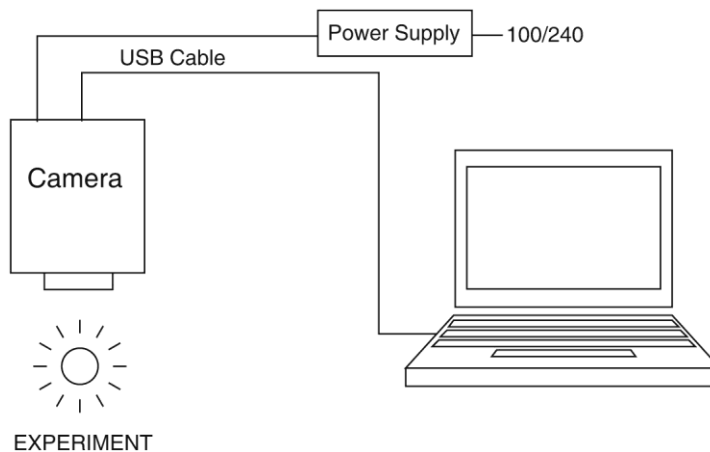


Figure 2. Typical Imaging Experiment Layout (Air-cooled Camera)

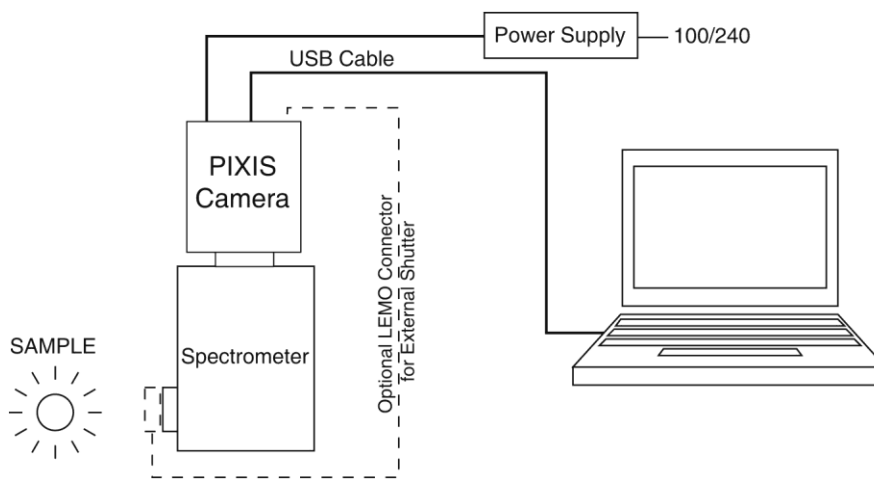


Figure 3. Typical Spectroscopy Experiment Layout (Air-cooled Camera)

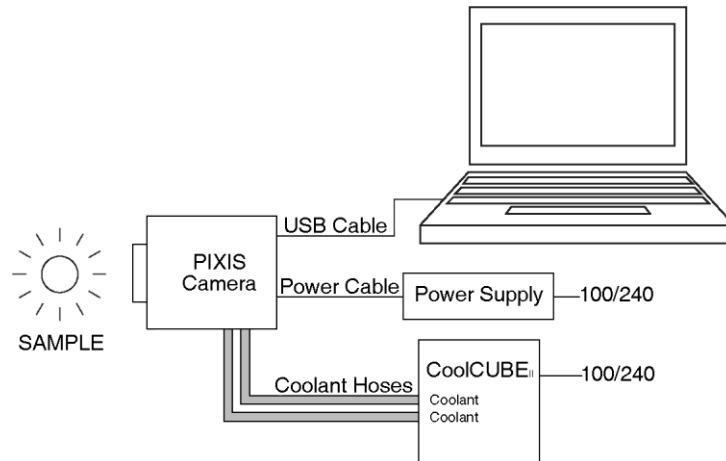


Figure 4. Typical Imaging Experiment Layout (Liquid-cooled Camera with CoolCUBE<sub>II</sub>)

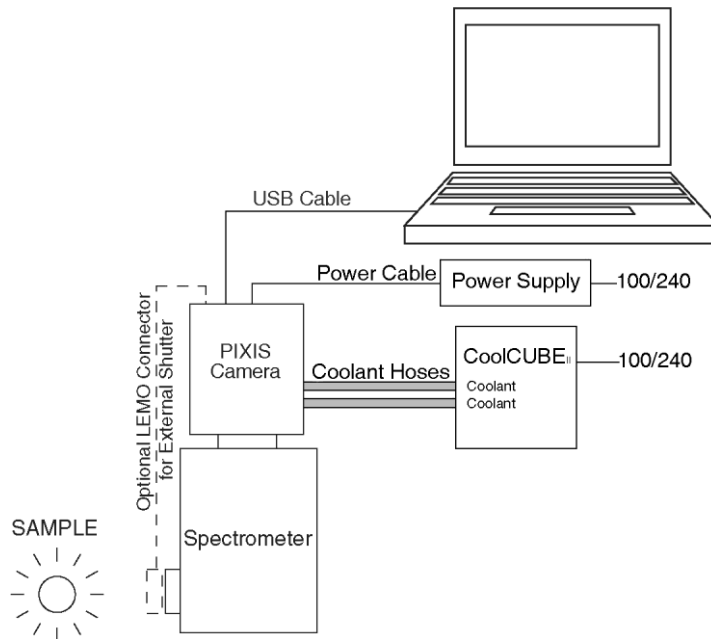


Figure 5. Typical Spectroscopy Experiment Layout (Liquid-cooled Camera with CoolCUBE<sub>II</sub>)

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## System Setup

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To minimize risk to users or to system equipment, turn the system **OFF** before any cables are connected or disconnected.

### Introduction

A PIXIS camera system consists of three hardware components:

- Camera head
- Power supply
- Cables

All of the components and cables required for your configuration are included with your shipment. Your PIXIS system has been specially configured and calibrated to match the camera options specified at the time of purchase. The CCD and coating you ordered have been installed in the camera head.

Keep all of the original packing materials so you can safely ship the PIXIS system to another location or return it for service if necessary. If you have any difficulty with any step of the instructions, call Princeton Instruments Customer Support. For contact information, refer to page 126.

Hardware installation may consist of:

- Installing an interface card, if the appropriate card is not already resident.
- Attaching a lens to a C-mount on the camera or to an F-mount adapter.
- Connecting the camera to an external shutter, if one is required.
- Mounting the camera to a spectrograph.

Software installation depends on the application software you will be using to run the system. Refer to the manual supplied with the software for information about installing and setting it up.

### Unpacking the System

During the unpacking, check the system components for possible signs of shipping damage. If there are any, notify Princeton Instruments immediately and file a claim with the carrier. If damage is not apparent but the camera cannot be operated, internal damage may have occurred in shipment. After unpacking the system, save the original packing materials so you can safely ship the camera system to another location or return it to Princeton Instruments for repairs if necessary.

## Checking the Equipment and Parts Inventory

Confirm that you have all of the equipment and parts required to set up the PIXIS system. A complete system consists of:

### Standard System:

- **Camera and Power Supply**
- **CoolCUBE<sub>II</sub> Circulator and hoses (for liquid-cooled system)**
- **Host Computer:** Can be purchased from Princeton Instruments or provided by user. For enhanced performance, a fast hard drive (10,000 rpm) and 2GB RAM is recommended.
- **Operating System:**
  - **WinView/32 or WinSpec/32:** Windows® XP (32-bit, SP3 or later), Vista ® (32-bit), or Windows® 7 (32-bit).
  - **LightField:** Windows® Vista (64-bit) or Windows® 7 (64-bit)
- **USB cable:** Five (5) meter cable (6050-0494) is standard.
- **PIXIS System User Manual**

### Options:

- **F-mount adapter**
- **Adjustable C- to Spectroscopy-mount kinetics adapter**
- **25 mm or 45 mm Internal Shutter** (as appropriate for the CCD size)
- **Application Software:**
  - **WinView/32 or WinSpec32** (Ver. 2.5.25 or later) **CD-ROM** (optional)
  - **LightField CD-ROM** (optional)
- **Software User Manual** (provided with application software)
- **Fiber Optic Extender Kit**

## System Requirements

### *Environmental Requirements*

Storage temperature:  $\leq 55^{\circ}\text{C}$

Operating environment temperature:  $+5^{\circ}\text{C}$  to  $+30^{\circ}\text{C}$ ; the environment temperature range over which system specifications can be guaranteed is  $+18^{\circ}\text{C}$  to  $+23^{\circ}\text{C}$

Relative humidity  $\leq 50\%$ ; non-condensing

**Note:** The cooling performance may degrade if the room temperature is above  $+23^{\circ}\text{C}$ .

**Ventilation:** Allow at least one inch clearance for the side air vents. Where the camera is inside an enclosure, > 30 cfm air circulation and heat dissipation of 100W is required.

**Power:** The PIXIS camera receives its power from the supplied power supply which in turn plugs into an AC power source.

### ***Host Computer***

**Note:** Computers and operating systems all undergo frequent revision. The following information is only intended to give minimum computer requirements. Please contact the factory to determine your specific needs.

### **WinX Requirements**

- Windows® XP (32-bit with SP3 or later), Vista® (32-bit), or Windows® 7 (32-bit)
- 2 GHz Pentium® 4 (or greater).
- Native USB 2.0 support on the mother board or USB 2.0 Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop; SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop)
- Minimum of 1 GB RAM (or greater).
- CD-ROM drive.
- Hard disk with a minimum of 1 Gbyte available. A complete installation of the program files takes about 17-50 Mbytes and the remainder is required for data storage, depending on the number and size of images/spectra collected. Disk level compression programs are not recommended. Drive speed of 10,000 RPM recommended.
- Super VGA monitor and graphics card supporting at least 65,535 colors with at least 128 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- Mouse or other pointing device.

### **LightField Requirements**

- Windows Vista® (64-bit) or Windows® 7 (64-bit)
- 2 GHz dual core processor
- 4 GB RAM (or greater)
- CD-ROM drive
- Super VGA monitor and graphics card supporting at least 65535 colors with at least 128 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- Hard disk with a minimum of 1 Gbyte available for installation. Additional space is required for data storage: the amount of space required depends on the number and size of images/spectra collected. Disk level compression programs are not recommended. Drive speed of 10,000 RPM recommended.
- Mouse or other pointing device.

**Note:** The above requirements are the minimum for operating a PIXIS camera. A faster computer with 5GB or larger memory (RAM) will greatly enhance the software performance during live mode operations.

## Software Installation

### WinX

#### Notes:

1. Before proceeding, please check to see if your computer supports USB 2.0. If it does not, install a USB 2.0 interface card. Follow the manufacturer's instructions.
2. Leave the USB cable disconnected from the camera until you have installed WinView/32 or WinSpec/32.

The following installation is performed via the WinView/32 or WinSpec/32 software installation CD.

1. On the **Select Installation Type** dialog (see Figure 6), click on **Typical** radio button to install the required drivers and the most commonly installed program files. Select the **Custom** radio button if you would like to choose among the available program files or do not want to install the drivers. **Complete** installs all of the application features.

The required INF, DLL, and USB driver files will be placed in the appropriate "Windows" directories (see Table 1 for locations).

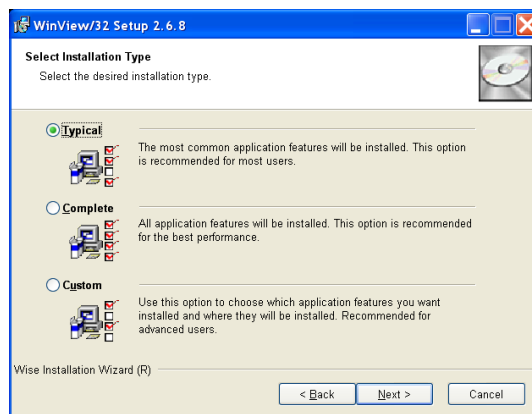


Figure 6. WinView Installation: Select Installation Type dialog

2. Make sure the camera is connected to the host computer and that the camera power supply is turned on.
3. Reboot the computer.
4. At bootup, Windows will detect the Princeton Instruments USB2 Interface hardware in the PIXIS. You may be prompted to enter the directory path(s) for the apausbprop.dll and/or the apausb.sys file(s), either by keyboard entry or by using the browse function.

Windows Version	USB INF Filename Located in "Windows"/INF directory*	USB Properties DLL Located in "Windows"/System32 directory	USB Device Driver Name Located in "Windows"/System32/Drivers directory
Windows® XP, Vista (32-bit), Windows 7 (32-bit)	rsusb2k.inf (in WINDOWS/INF, for example)	apausbprop.dll (in WINDOWS/System32, for example)	apausb.sys (in WINDOWS/System32/Drivers, for example)

\* The INF directory may be hidden.

Table 1. USB Driver Files and Locations



## LightField

The following installation is performed via the LightField software installation CD.

1. Before starting the installation:
  - Verify that the computer operating system is Windows Vista (64-bit) or Windows 7 (64-bit).
  - Confirm that your computer supports USB 2.0. If it does not, please refer to the manufacturer's instructions for installing a USB 2.0 interface card.
  - Verify that your computer is connected to the Internet. Internet connection is required for product activation.
2. Insert the CD and follow the installation wizard prompts.

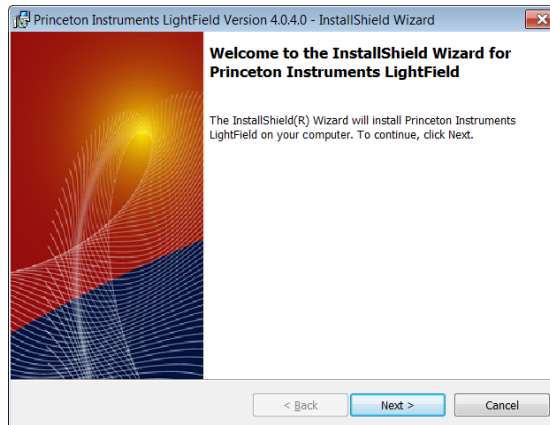


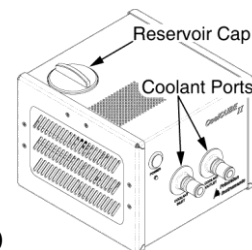
Figure 7. LightField Installation Wizard dialog

3. After the installation finishes, reboot the computer.
4. Connect the PIXIS system components to your computer and power them on.
5. Start LightField, activate it, and begin setting up your experiment.

## Making the Camera-Circulator Connections for a CoolCUBE<sub>II</sub>

For liquid-cooled cameras, the CoolCUBE<sub>II</sub> circulator provides a vibration-free method of heat removal.

1. Make sure the camera and the circulator power switches are turned off.
2. Make sure the circulator is 6 inches (150 mm) or more below the camera. The vertical distance should not exceed 10 feet (3 m). Typically, the camera is at table height and the circulator is on the floor.
3. Make the coolant connections between the circulator and the camera. It does not matter which hose from the circulator is plugged into a coolant port on the camera.
4. It is recommended that hoses be secured to the camera hose barbs with the clamp supplied.



**Notes:**

1. Make sure that there are no kinks in the hoses that impede the coolant flow. Lack of sufficient flow can seriously harm the detector and any resulting damage is not covered under warranty.
2. Damage caused by water leaking into the PIXIS voids the warranty.
5. Unscrew the reservoir cap (on top of the CoolCUBE<sub>II</sub>) and make sure that the coolant reservoir contains coolant. If additional coolant is required, fill with a 50:50 mixture of water and ethylene glycol.
6. Screw the reservoir cap back in.
7. Plug the circulator into a 100-240 VAC, 47-63 Hz power source.
8. Turn the circulator on. Make sure there are no leaks or air bubbles in the hoses.



**Note:** Small air bubbles (about the size of bubbles in soda) are common in the CoolCUBE<sub>II</sub> especially at start up and do not prevent proper operation.

- If there are no problems, continue to Step 9.
  - If there are leaks or air bubbles, turn the circulator off and correct the problem(s) by securing the hoses or adding more coolant to the reservoir. Turn the circulator back on. Recheck and if there are no problems, continue to Step 9.
9. Turn the camera on.
  10. Start the application software.

## Entering the Default Camera System Parameters

The following instructions assume that you have performed the computer interface installation.

### WinX

1. Make sure the PIXIS is connected to the host computer and that it is turned on.
2. Run the WinX application. The **Camera Detection wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard...** button on the **Controller/CCD** tab to start the wizard.
3. On the **Welcome** dialog (Figure 8), leave the checkbox unselected and click on **Next**.

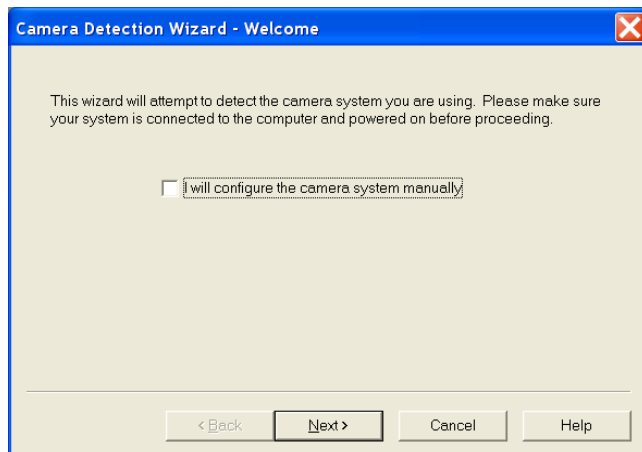


Figure 8. Camera Detection Wizard - Welcome dialog

4. Follow the instructions on the dialogs to perform the initial hardware setup: this wizard enters default parameters on the Hardware Setup dialog tabs and gives you an opportunity to acquire a test image to confirm the system is working.

**Note:** For a step-by-step procedure on basic system operation (Imaging and Spectroscopy), refer to the appropriate "*First Light*" sections: for Imaging applications (page 33) or for Spectroscopy applications (page 37).

### LightField

1. Make sure the PIXIS (and spectrograph, if this is a spectroscopy system) is connected to the host computer and that the camera (and spectrograph) power supply is turned on.
2. Start LightField.
3. While LightField is starting up, it will detect the available device(s) and load the appropriate icons into the **Available Devices** area in the **Experiment** workspace.
4. When you drag an icon into the **Experiment Devices** area, the appropriate expanders will be loaded into the **Experiment Settings** stack on the lefthand side of the window.

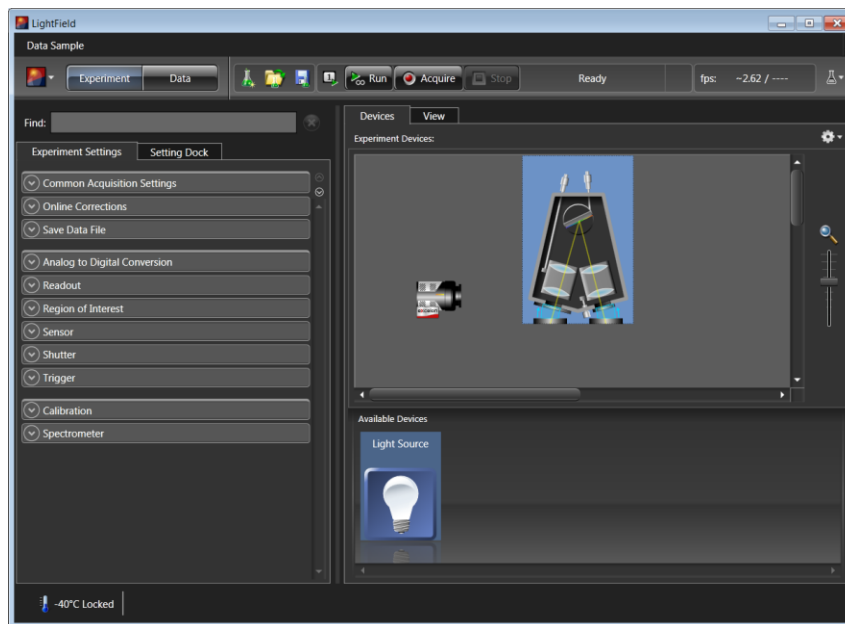


Figure 9. LightField Experiment Workspace

- Because this is a new experiment, the default settings will automatically be entered for the experiment device(s). These settings will allow you to begin previewing (**Run** button) or acquiring (**Acquire** button) data.

**Note:** For a step-by-step procedure on basic system operation, refer to the appropriate "*First Light*" sections: for Imaging applications (page 43) or for Spectroscopy applications (page 46).

## Attaching Lenses to C- and F-Mount Adapters

**Caution** **Overexposure protection:** Cameras that are exposed to room light or other continuous light sources will quickly become saturated. Set the lens to the smallest aperture (highest f-number) and cover the lens with a lens cap to prevent overexposure.

PIXIS cameras for imaging applications incorporate an integral C-mount adapter, an adjustable C-mount adapter, or an integral F-mount adapter. *Other mounts may be available. Consult the factory for specific information relating to your needs. See page 126 for Information on accessing the Princeton Instruments Customer Support Dept.*

### Attaching to a C-Mount Adapter

C-mount lenses simply screw into the front of these cameras. Tighten the lens by hand only. An optional C-to-F-mount adapter, which uses the Nikon bayonet format, can be ordered. For information about adjusting the focal distance for an adjustable C-mount adapter, refer to the instructions on page 107.

**Note:** C-mount cameras are shipped with a dust cover lens installed. Although this lens is capable of providing surprisingly good images, its throughput is low and the image quality is not as good as can be obtained with a high-quality camera lens. Users should replace the dust-cover lens with their own high-quality laboratory lens before making measurements.

### ***Attaching to an F-Mount Adapter***

F-mount adapters use the Nikon bayonet format. To mount the lens on the camera:

1. Locate the large indicator dot on the side of the lens.
2. Note the corresponding dot on the front side of the adapter.
3. Line up the dots and slide the lens into the adapter.
4. Turn the lens counterclockwise until a click is heard. The lens is now locked in place.

In addition to the focusing ring of the lens, there is provision for focusing the adapter itself. That adjustment is secured by setscrews on the side of the adapter's adjustment ring. Directions for focusing the adapter *and* the lens are provided on pages 108 and 109.

## **Mounting the Adjustable C- to Spectroscopy-Mount Kinetics Adapter**

The adjustable spectroscopy-mount kinetics adapter allows you to move the camera vertically at the exit plane of an Acton Series spectrograph in order to align the kinetics rows at the middle of the focal plane for the best spectral quality. The adapter is mounted to the front of a PIXIS camera and is secured to the camera by a threaded insert screwed into the camera's C-mount opening. Refer to Figure 10 when mounting the adapter to the camera.

### **Tools Required:**

- 0.050" Hex key
- 3/32" hex key
- Flat screwdriver
- Spanner wrench (1.17"/29.7 mm between 0.094"/2.38 mm diameter holes)

### **Equipment:**

- Acton Series Spectrograph with light source at entrance port
- Kinetics Adapter
  - SP-2150 and SP-2750 Spectrographs: Use the Model 7050-0107 adapter
  - SP-2350 and SP-2550 Spectrographs: Use the Model 7050-0104 adapter
- Camera with C-mount nose

### **Procedure:**

1. If a light baffle is mounted to the front of the adapter, remove the two 2-56 screws securing it and set the baffle aside.
2. Orient the adapter with the setscrew at the top (see Figure 10) and, using a spanner wrench or equivalent (distance between holes is 1.17" [29.7 mm]), tighten the threaded insert into the C-mount opening on the camera.
3. If you are using a light baffle, mount the light baffle to the front of the adapter.
4. Rotate the sliding tube as you gently insert it into the spectrograph's exit port.
5. With the spectrograph, camera, and light source powered on and connected to the computer (as required), start the application software. Refer to the appropriate **"First Light"** instructions in this manual when focusing and rotationally aligning the camera to the spectrograph optics.

6. When you have finished with focusing and rotational alignment, secure the sliding tube in place with the spectrograph setscrews.
7. If they have already been installed, loosen the adapter's two recessed locking setscrews (use a 0.050 hex key). If they have not been installed, insert the setscrews into the holes at the sides of the adapter and screw them in a couple of turns.
8. When the camera opening is centered within the sliding tube, you can adjust the camera up or down .4" (4.06 mm) by tightening or loosening the vertical adjustment setscrew (use a 3/32" hex key).
9. After you have completed the adjustment, tighten the recessed locking setscrews in the adapter flange to lock the position.

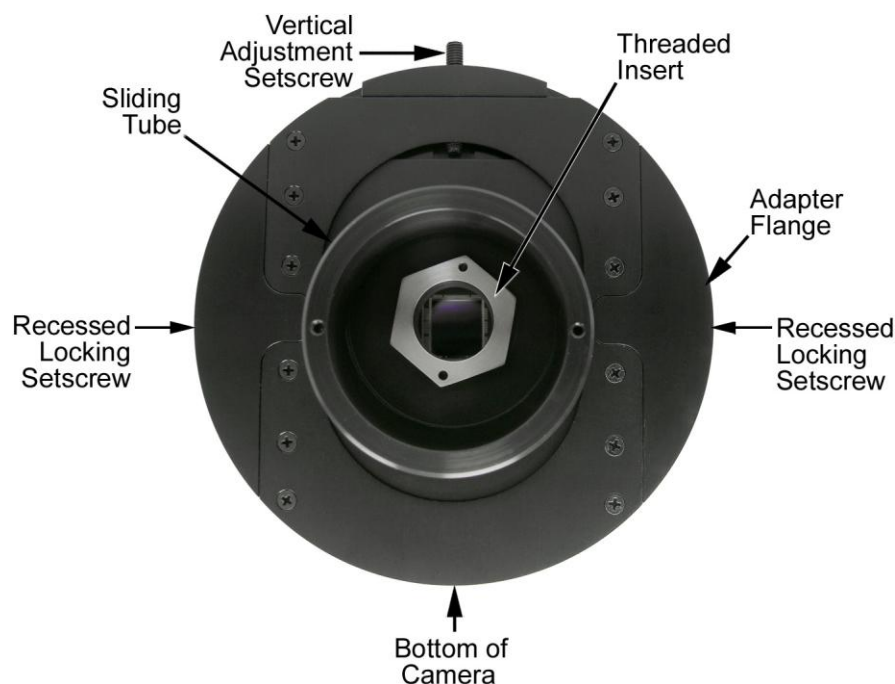


Figure 10. Adjustable C- to Spectroscopy-Mount Kinetics Adapter

## Mounting the Camera to a Spectrograph

The camera must be properly mounted to the spectrograph to focus. Additional precautions must also be taken to prevent overexposure of the camera.

The distance to the focal plane from the front of the mechanical assembly depends on the specific configuration. Refer to "*Focal Distance*" on page 91 for more information.

### ***Spectrograph Adapter***

Refer to Appendix C, page 111 for instructions for a variety of adapters. *Other adapters may be available. Consult the factory for specific information relating to your needs.*

## Connecting an External Shutter

**WARNING!** Disconnecting or connecting the shutter cable to the camera while the camera is **ON** can destroy the shutter or the shutter driver in the camera!

### Introduction

Typically, PIXIS cameras for imaging applications are shipped with an internal shutter. The 25 or 45 mm internal shutter (depending on the CCD array size) is housed in the main body. Typically, cameras for spectroscopy applications do not incorporate internal shutter. However, for cameras without an internal shutter, there is provision for connecting an external 25 or 45 mm shutter (supplied by Princeton Instruments) at the **Shutter** connector on the rear of the PIXIS.

### Cautions

1. **DO NOT** connect a Princeton Instruments-supplied external shutter when there is an installed internal shutter. Permanent damage to the shutter driver may occur.
2. Electromechanical shutters typically have a lifetime of about a million cycles. Avoid running the shutter unnecessarily.
3. A shutter can become overheated when short, rapidly repeated exposures are used or if the shutter is held open for an extended period of time. Newer versions of the WinView/WinSpec software and camera hardware monitor the temperature of **45 mm internal shutters** to prevent overheating conditions. *The temperature of external shutters is NOT monitored!*

### External Shutter

A Princeton Instruments-supplied external shutter may be used with a PIXIS camera that does not have an internal shutter. In most cases, the external shutter will be mounted on the entrance slit of a spectrograph. The shutter mount used with all Acton Series spectrographs requires no disassembly. Mount it to the spectrograph as shown in Figure 11. In the case of the IsoPlane SCT-320 spectrograph, the shutter assembly is mounted internally: refer to the instructions provided in the IsoPlane manual.

### Shutter Cable Connection

1. Verify that the PIXIS camera is turned OFF (i.e., the power supply is switched OFF).
2. Verify that there is no internal shutter.

### Caution

If the camera is equipped with an internal shutter, **DO NOT USE** the **Shutter** connector to drive an external (second) shutter. Such a configuration will result in under-powering both shutters and may cause damage to the system.

3. Connect the shutter cable to the LEMO® connector at the rear of the camera.
4. Power the PIXIS camera ON.

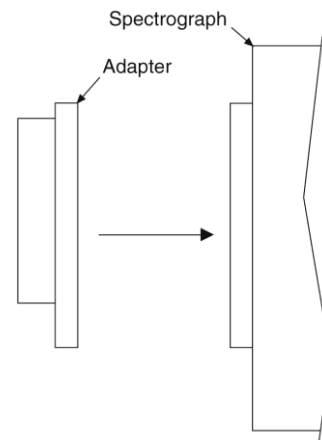


Figure 11. Acton Series Spectrograph Entrance Slit Mount

**Overexposure Protection**

Cameras that are exposed to room light or other continuous light sources will quickly become saturated. This most often occurs when operating without a shutter. If the camera is mounted to a spectrograph, close the entrance slit of the spectrograph to reduce the incident light.

**Note:** If the CCD is cooled to low temperatures (below  $-50^{\circ}\text{C}$ ), exposure to ambient light will over-saturate it. This may increase dark charge significantly. If the camera remains saturated after all light sources are removed, you may have to bring the camera back to room temperature to restore dark charge to its original level.



## Operation

### Introduction

Once the PIXIS camera has been installed as explained in the preceding chapters, operation of the camera is straightforward. In most applications you simply establish optimum performance using the **Focus** mode (in WinX, for example), set the target camera temperature, wait until the temperature has stabilized, and then do actual data acquisition in the **Acquire** mode. Additional considerations regarding experiment setup and equipment configuration are addressed in the software manual.

During data acquisition, the CCD array is exposed to a source and charge accumulates in the pixels. After the defined exposure time, the accumulated signal is readout of the array, digitized, and then transferred to the host computer. Upon data transfer, the data is displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in Figure 12.

Whether or not the data is displayed and/or stored depends on the data collection operation that has been selected in the application software.

In WinX and LightField, the data collection operations use the Experiment Setup parameters to establish the exposure time (the period when signal of interest is allowed to accumulate on the CCD). **Focus {Preview}** is more likely to be used in setting up the system (see the "**First Light**" discussions) and **Acquire** is then used for the collection and storage of data. Briefly:

- In **Focus {Preview}** mode, the number of frames is ignored. A single frame is acquired and displayed, another frame is acquired and overwrites the currently displayed data, and so on until **Stop** is selected. In WinX, the last frame acquired before **Stop** is selected can be stored; in LightField, this frame cannot be stored. **Focus {Preview}** mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.
- In **Acquire** mode, every frame of data collected can be automatically stored (the completed dataset may include multiple frames with one or more accumulations). This mode would ordinarily be selected during actual data collection. One limitation of **Acquire** mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow may occur. In WinX, this could only happen in Fast Mode operation.

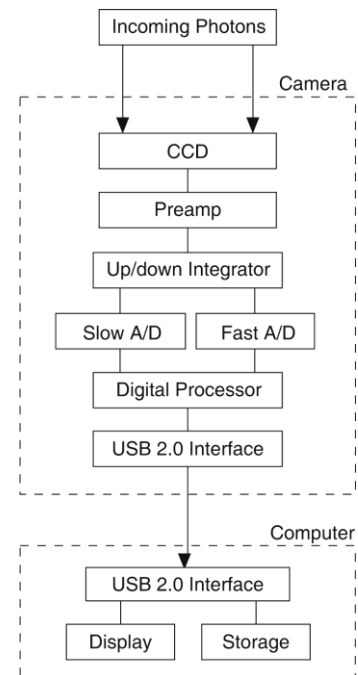


Figure 12. Block Diagram of PIXIS System

The remainder of this chapter provides "First Light" procedures (these provide step-by-step instruction on how to initially verify system operation) and discusses factors that affect exposure, readout, and digitization of the incoming signal. By understanding the exposure, readout, and digitization factors and making adjustments to software settings you can maximize signal-to-noise ratio. For information about synchronizing data acquisition with external devices, please refer to *Chapter 6, Advanced Topics*.

## System On/Off Sequences

For WinView/32 and WinSpec/32, the following on/off sequences must be followed to establish and maintain the communication link between the camera and the host computer:

1. The PIXIS camera must be powered ON **before** the WinX application is opened to ensure communication between the camera and the computer. If the WinX application is opened and the PIXIS is not powered ON, many of the functions will be disabled and you will only be able to retrieve and examine previously acquired and stored data. You must close the WinX application, power the camera ON, and reopen the application before you can set up experiments and acquire new data.
2. The WinX application must be closed before powering the camera OFF. If you power the camera OFF before closing the application, the communication link with the camera will be broken. You can operate the program in a playback mode (i.e., examine previously acquired data) but will be unable to acquire new data until you have closed the application, powered the camera ON, and then re-opened the application.

## WinX First Light Instructions

### *Imaging*

This section provides step-by-step instructions for acquiring an imaging measurement for the first time. The intent of this procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

### Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapter 4.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in imaging mode.
5. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

### Getting Started

1. Mount a test target in front of the camera.
2. Power ON the camera (i.e., switch the power supply ON).

**Note:** The camera must be turned on before WinX is opened, and WinX must be closed before the camera is turned off.

3. Turn on the computer power.
4. Start the application software.

### Setting the Parameters

**Note:** The following procedure is based on WinView/32: you will need to modify it if you are using a different application. Basic familiarity with the WinView/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

**Environment dialog (Setup|Environment):** Check the DMA Buffer size. Large arrays (2048x2048, for example) require a buffer size on the order of 32 Mbytes. If you change the buffer size, you will have to *reboot the computer* for this memory allocation to be activated, and then restart WinView.

**Controller|Camera tab (Setup|Hardware):** These parameters should be set automatically to the proper values for your system.

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** None or Small (System dependent).
- **Readout mode:** Available modes are read from the camera. Select Full frame.

**Detector Temperature (Setup|Detector Temperature...):** The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog will report that the temperature is **LOCKED**. Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within  $\pm 0.05^\circ\text{C}$ .

**Note:** The Detector Temperature dialog will not display temperature information while you are acquiring data.

**Cleans and Skips tab (Setup|Hardware):** Click on **Load Default Values** and click on **Yes**.

**Experiment Setup Main tab (Acquisition|Experiment Setup...):**

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1

**Experiment Setup ROI tab (Acquisition|Experiment Setup...):** Use this function to define the region of interest (ROI).

- **Imaging Mode:** Select this mode if you are running WinSpec.
- Clicking on **Full** loads the full size of the chip into the edit boxes.

**Experiment Setup Timing tab (Acquisition|Experiment Setup...):**

- **Timing Mode:** Free Run
- **Shutter Control:** Normal
- **Safe Mode vs. Fast Mode:** Fast

**Confirming the Setup**

1. If you are using WinView/32 and the computer monitor for focusing, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired.
2. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Some imaging tips follow:
  - Begin with the lens blocked off and then set the lens at the smallest possible aperture (largest f-stop number).
  - Make sure there is a suitable target in front of the lens. An object with text or graphics works best.
  - Adjust the intensity scaling (by clicking the **5%-95%** button at the bottom left corner of the data window) and adjust the lens aperture until a suitable setting is found. Once you've determined that the image is present, select a lower setting for better contrast. Check the brightest regions of the image to determine if the A/D converter is at full-scale. *A 16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535.* Adjust the aperture to where it is just slightly smaller (higher f-stop) than the setting where maximum brightness on any part of the image occurs.
  - Set the focus adjustment of the lens for maximum sharpness in the viewed image.
  - In the case of a camera with an F-mount, the camera lens adapter itself also has a focus adjustment. If necessary, this focus can be changed to bring the image into range of the lens focus adjustment. See "**F-Mount Adapter Focusing Procedure**", page 108.
3. After you have focused the camera, you can stop **Focus** mode, continue **Focus** mode, begin **Acquire** mode, or wait for the CCD to reach the operating temperature before going to **Acquire** mode.

### ***Spectroscopy***

The following paragraphs provide step-by-step instructions for operating PIXIS in a spectroscopy setup for the first time. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the camera is to be operated with a spectrograph (such as an Acton Series 2300 spectrograph) on which it has been properly installed (refer to Appendix D for instructions for mounting a spectrograph adapter to the PIXIS). A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

### **Assumptions**

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapter 4.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in spectroscopy mode.
5. The PIXIS does not have an internal shutter.
6. The spectrograph has an entrance slit shutter that is being controlled by the PIXIS via the **Shutter** connector.

### **Caution**

If the PIXIS has an internal shutter, **DO NOT USE** the **Shutter** connector to drive a spectrograph entrance slit shutter. If both the camera and the spectrograph have shutters, the entrance slit shutter will have to be removed or a Princeton Instruments SHC-EXT Shutter Control Box may be used to control the opening and closing of the entrance slit shutter. See the spectrograph manual.

### **Getting Started**

1. Set the spectrograph entrance slit width to minimum (10  $\mu\text{m}$  if possible).
2. Power ON the spectrograph (i.e., switch the power supply ON).
3. Mount a light source at the spectrograph entrance slit.
4. Mount the camera to the spectrograph exit port.
5. Connect the shutter cable between the entrance slit shutter and the PIXIS **Shutter** connector.
  - **External Slit Shutter:** A shutter assembly mounted externally to the spectrograph has shutter cable that plugs into the **Shutter** connector.

- **Internal Slit Shutter:** A shutter mounted internally has an external shutter connector in the sidewall of the spectrograph. Connect a shutter cable from the PIXIS **Shutter** connector to that connector.
6. Power ON the camera (i.e., switch the power supply ON).

**Note:** With USB 2.0, the camera must be turned on before WinX is opened, and WinX must be closed before the camera is turned off.

7. Turn on the computer power.
8. Start the application software.

### Setting the Camera Parameters

**Note:** The following procedure is based on WinSpec/32: you will need to modify it if you are using a different application. Basic familiarity with the WinSpec/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

**Environment dialog (Setup|Environment):** Check the DMA Buffer size. Large arrays (2048x2048, for example) require a buffer size on the order of 32 Mbytes. If you change the buffer size, you will have to *reboot the computer* for this memory allocation to be activated, and then restart WinSpec.

**Controller|Camera tab (Setup|Hardware):** These parameters should be set automatically to the proper values for your system.

- **Controller type:** This information is read from the camera.
- **Camera type:** This information is read from the camera.
- **Shutter type:** Remote (entrance slit shutter). You would select None if the camera had no shutter and was not controlling an entrance slit shutter.
- **Readout mode:** Available modes are read from the camera. Select Full frame.

**Detector Temperature (Setup|Detector Temperature...):** The default temperature setting is read from the camera. When the array temperature reaches the set temperature, the **Detector Temperature** dialog will report that the temperature is **LOCKED**. Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within  $\pm 0.05^\circ\text{C}$ .

**Note:** The Detector Temperature dialog will not display temperature information while you are acquiring data.

**Cleans and Skips tab (Setup|Hardware):** Click on **Load Default Values** and click on **Yes**.

**Experiment Setup Main tab (Acquisition|Experiment Setup...):**

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1

**Experiment Setup ROI tab (Acquisition|Experiment Setup...):** Use this function to define the region of interest (ROI).

- **Spectroscopy Mode:** Selected
- Clicking on **Full** loads the full size of the chip into the edit boxes.

**Experiment Setup Timing tab (Acquisition|Experiment Setup...):**

- **Timing Mode:** Free Run
- **Shutter Control:** Normal
- **Safe Mode vs. Fast Mode:** Fast

**Setting the Spectrograph Parameters**

1. **Define Spectrograph dialog (Spectrograph|Define):** Click on **Install/Remove Spectrograph**, highlight the appropriate spectrograph name in the **Supported Spectrographs** list (for example, **Acton SP-300i** for an Acton SP-2300i or **Acton SCT320** for an IsoPlane), and click on **Install Selected Spectrograph**.
2. **Move Spectrograph dialog:** Choose the grating to be move, and then set it to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

**Confirming the Setup**

1. Turn on the light source at the spectrograph entrance slit.
2. In WinSpec, select **Focus** (on the **Acquisition** menu or on the **Experiment Setup** dialog) to begin data accumulation. Depending on the display settings, you should see either a spectral band (image) or a graph. Background noise will decrease as the camera cools to its default temperature.
3. Turn off the light source. The data displayed should change to a background noise pattern or low intensity graph. If this occurs, you have confirmed that light entering the spectrograph is being seen by the camera. Skip Steps 4-5 and continue to the “**Focusing**” topic on page 40.
4. If there is no difference between the data displayed when the light source is on or off:
  - a. Verify that the light source has power and is turned on.
  - b. Verify that the entrance slit is open at least 10  $\mu\text{m}$ .
  - c. Check the **Exposure Time** (**Experiment Setup Timing** tab).
  - d. Confirm that **Shutter Control** is set to **Normal** (**Experiment Setup Timing** tab).
  - e. Check the shutter cable connections.
  - f. Verify shutter operation. You should hear the shutter open and close while running in **Focus** mode.
    - If you hear a shutter operating and you have done Steps a-e, turn the light source on, wait a minute and then turn the light off while you view the data display. If

the problem is fixed, stop acquisition or continue to the “*Focusing*” topic on page 40; otherwise, **stop data acquisition** and continue to Step g.

- If you do not hear a shutter operating and you have done Steps a-e, **stop data acquisition** and continue to Step g.
- g. Make sure the spectrograph has an entrance slit shutter. An externally mounted shutter is easily confirmed. Verifying an internally mounted shutter requires access to the inside of the spectrograph: refer to the spectrograph manual for instructions.
  - h. Check to see if the PIXIS has a shutter. Loosen and remove the camera from the spectrograph. If you see the CCD when you look into the front of the camera, the camera does not have an internal shutter. Re-mount the camera to the spectrograph.
  - i. If the camera and spectrograph both have shutters, permanent damage to the shutter driver may occur. You can either disconnect and remove the entrance slit shutter or control it via a Princeton Instruments SHC-EXT Control Box. To disconnect and remove an entrance slit shutter:
    - **External Slit Shutter:** Disconnect the shutter cable and remove the shutter assembly from the spectrograph entrance port.
    - **Internal Slit Shutter:** Disconnect the shutter cable. Removing an internally mounted shutter requires access to the inside of the spectrograph: refer to the spectrograph manual for removal instructions.
5. If you need more help, contact Customer Support. See page 126 for contact information.

### **Focusing**

The mounting hardware provides two degrees of freedom, focus and rotation. In this context, focus means to physically move the camera back and forth through the focal plane of the spectrograph. The approach taken is to slowly move the camera in and out of focus and adjust for optimum while watching a live display on the monitor, followed by rotating the camera and again adjusting for optimum. The following procedure, which describes the focusing operation with an Acton SP-2300i spectrograph, can be easily adapted to other spectrographs. For IsoPlane SCT-320 related focusing information, see “*IsoPlane SCT-320 Spectrograph*” on page 42.

### **Caution**

If the PIXIS has an internal shutter, **DO NOT USE** the **Shutter** connector to drive a spectrograph entrance slit shutter. If both the camera and the spectrograph have shutters, the entrance slit shutter will have to be removed or a Princeton Instruments SHC-EXT Shutter Control Box may be used to control the opening and closing of the entrance slit shutter. See the spectrograph manual.

### **Acton Series Spectrograph**

1. Mount a light source such as a mercury pen-ray type in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no “line” sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.



2. With the spectrograph properly connected to the camera, turn the power on, wait for the spectrograph to initialize.
3. Select **Define** from the **Spectrograph** menu, click on **Install/Remove Spectrograph**, highlight the appropriate spectrograph name (for example, **Acton SP300i** for an Acton SP-2300i spectrograph) in the **Supported Spectrographs** list, and click on **Install Selected Spectrograph**.
4. Select **Move** from the **Spectrograph** menu, choose the grating to be move, and then set it to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

**Hint:** Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrograph. Select 500 nm as the spectral line.

5. Set the slit to 10  $\mu\text{m}$  at a minimum. *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
6. Wait until the detector temperature locks at its default temperature.
7. In WinSpec, select **Focus** (on the **Acquisition** menu or on the **Experiment Setup** dialog) to begin data accumulation. Data will be continuously acquired and displayed but will not be stored until you stop acquisition and use the **Save** function on the **File** menu.
8. Slowly move the camera in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Leave the camera set for the narrowest achievable line. You may want to use the **Focus Helper** function (**Process|Focus Helper...**) to determine the narrowest line width: it can automatically locate peaks and generate a report on peak characteristics during live data acquisition (see the WinSpec/32 on-line help for more information).

Note that the way focusing is accomplished depends on the spectrograph, as follows:

- **Long focal-length spectrographs such as the Acton SP-2300:** The mounting adapter includes a tube that slides inside another tube to move the camera in or out as required to achieve optimum focus.
  - **Short focal-length spectrographs:** There is generally a focusing mechanism on the spectrograph itself which, when adjusted, will move the optics as required to achieve proper focus.
  - **No focusing adjustment:** If there is no focusing adjustment, either provided by the spectrograph or by the mounting hardware, then the only recourse will be to adjust the spectrograph's focusing mirror.
9. Next adjust the rotation. You can do this by rotating the camera while watching a live display of the line (you may need to loosen two setscrews securing the spectrograph adapter). Choose a peak to monitor during the rotational alignment. This peak will go from broad to narrow and back to broad. Leave the camera rotation set for the narrowest achievable peak.

Alternatively, take an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the camera until the line shape on the screen is parallel with the vertical bar.

**Note:** When aligning other accessories, such as fibers, lenses, optical fiber adapters, first align the spectrograph to the slit. Then align the accessory without disturbing the camera position. The procedure is identical to that used to focus the spectrograph (i.e., do the focus and alignment operations while watching a live image).

10. Tighten the spectrograph set screws to secure the spectrograph adapter. Then stop data acquisition.

### IsoPlane SCT-320 Spectrograph

Because the PIXIS is mounted directly to the mounting plate on the IsoPlane, focusing and alignment is different from the way that focusing and alignment are performed for an Acton Series spectrograph. The following information assumes that you are familiar with the locations of the mounting plate, Micrometer Compartment, and the locking set screw. If not, refer to the IsoPlane manual supplied with the spectrograph.

1. Mount an Acton light source such as the dual HG/NeAr source in front of the entrance slit of the spectrograph.
2. With the spectrograph properly connected to the computer, turn the power on, wait for the spectrograph to initialize.
3. With the PIXIS mounted to the spectrograph and connected to the computer, turn on the power and wait for the detector to initialize.
4. Boot the WinSpec software. Select **Define** from the **Spectrograph** menu, click on **Install/Remove Spectrograph**, highlight “**Acton SCT320**” in the **Supported Spectrographs** list, and click on **Install Selected Spectrograph**.
5. Select **Move** from the **Spectrograph** menu, choose the grating to be move, and then set it to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.
6. Set the slit to 10  $\mu\text{m}$  at a minimum. *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
7. Wait until the detector temperature locks at its default temperature.
8. Remove the cover from the Micrometer Compartment.
9. Using a 3/32” hex wrench, loosen the locking set screw.
10. Turn on **Focus** mode.
11. While continuously acquiring data, adjust the micrometer until you maximize the intensity level of a selected peak or peaks.
12. Tighten down the locking set screw.
13. Place the Micrometer Cover on the spectrograph. Replace and tighten all of the cover screws.
14. Next adjust the rotation. First, use a 9/64” hex wrench to loosen the four screws at the corners of the detector mounting plate. While watching a live display of the spectrum, select a peak to monitor and then rotate the detector (up to 4 degrees of rotation are possible). The peak will go from broad to narrow and back to broad. Leave the detector rotation set for the narrowest achievable peak.  
  
Alternatively, take an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the detector until the line shape on the screen is parallel with the vertical bar.
15. After completing the rotational alignment, re-tighten the four mounting plate screws. Then stop acquisition.

## LightField First Light Instructions

### ***Imaging***

This section provides step-by-step instructions for acquiring an imaging measurement in LightField for the first time. The intent of this procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

### **Assumptions**

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in the previous chapters.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in imaging mode.
5. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

### **Getting Started**

1. Mount a test target in front of the camera.
2. Power ON the camera (the power switch is on the back of the power supply).
3. Turn on the computer power.
4. Start the application software.

### **Setting the Parameters**

**Note:** The following procedure is based on LightField. Basic familiarity with the LightField software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

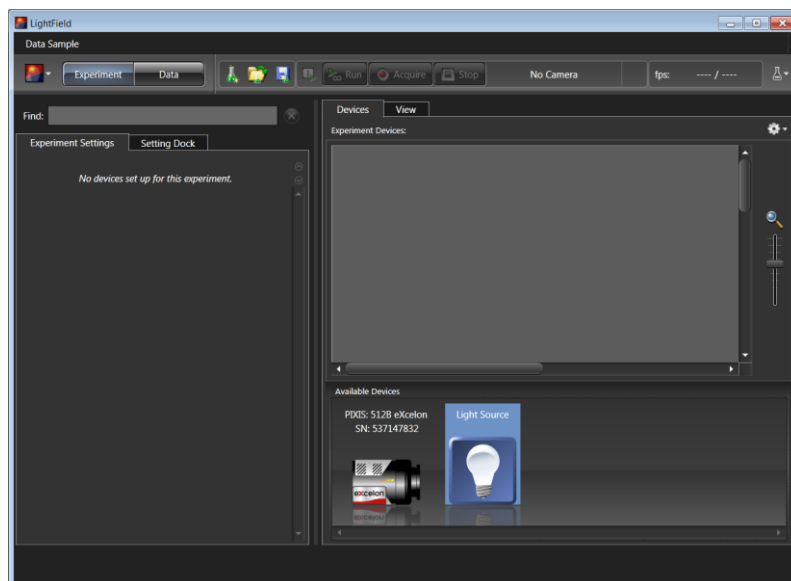


Figure 13. Available Devices Area

1. After LightField opens, you should see an icon representing your camera in the **Available Devices** area. In the figure above, the camera is a PIXIS:512B eXcelon<sup>®</sup>.
2. Drag the icon into the **Experiment Devices** area.

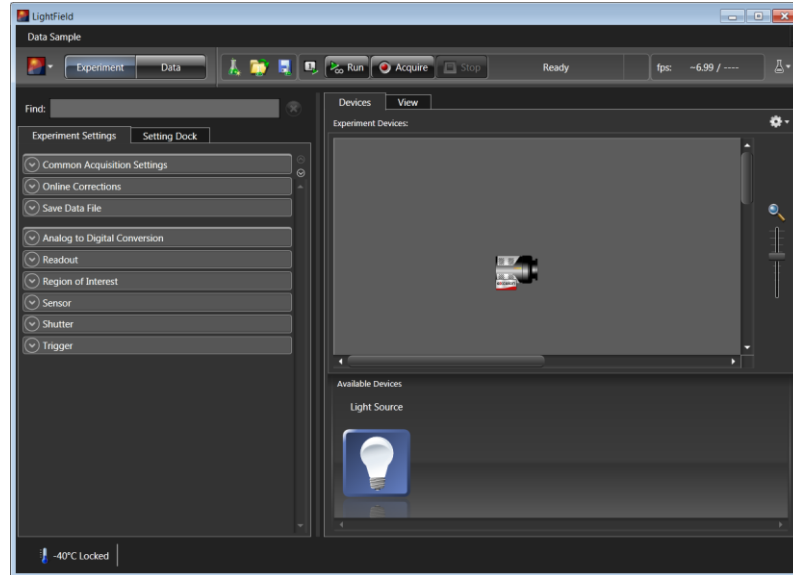


Figure 14. Experiment Devices Area

3. Note that the **Experiment Settings** stack on the left now displays several expanders. Because this is a new experiment, the default settings for the camera will be active. The **Status** bar (at the bottom of the window) displays an icon for temperature status.

Temperature status reports the current temperature and whether the set temperature has been reached. Clicking on the icon, opens the **Sensor** expander which is where the set temperature can be changed.

### Confirming the Setup

1. Click on the **View** tab, just above **Experiment Devices**, to change to the display area.
2. Wait until the camera locks at its default temperature.

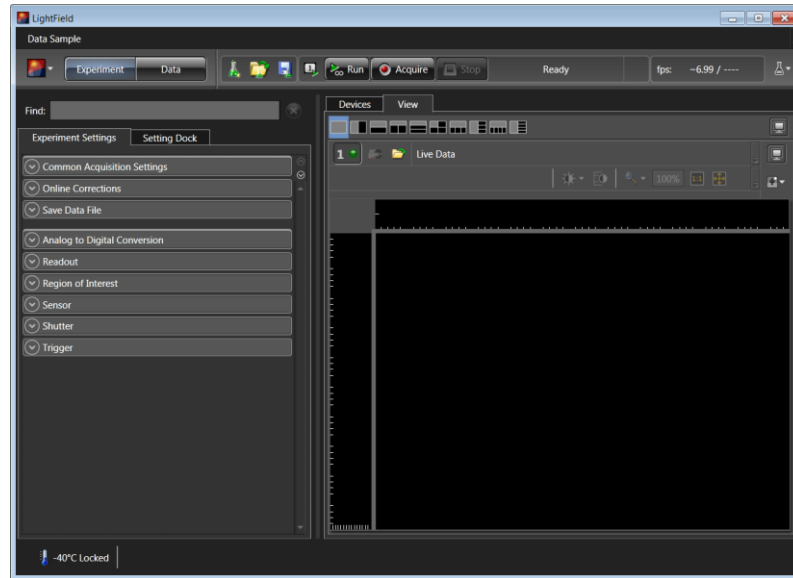


Figure 15. View Area

3. Click on the **Run** button  to start **Preview** mode. In this mode, images will be continuously acquired and displayed.

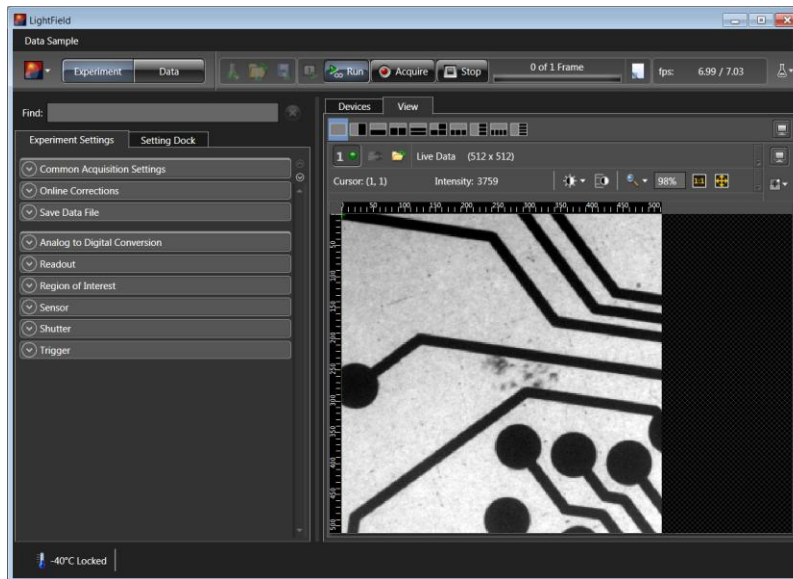


Figure 16. View Area Displaying an Image

4. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Some imaging tips follow:
  - Begin with the lens blocked off and then set the lens at the smallest possible aperture (largest f-stop number).
  - Make sure there is a suitable target in front of the lens. An object with text or graphics works best.

- Check the brightest regions of the image to determine if the A/D converter is at full-scale. *A 16-bit A/D is at full scale when the brightest parts of the image reach an intensity of 65535.* Adjust the aperture to where it is just slightly smaller (higher f-stop) than the setting where maximum brightness on any part of the image occurs.
  - Set the focus adjustment of the lens for maximum sharpness in the viewed image.
5. After you have focused the camera, you can stop **Preview** mode, continue **Preview** mode, or begin **Acquire** mode.

### ***Spectroscopy***

The following paragraphs provide step-by-step instructions for operating a PIXIS in a spectroscopy setup in LightField for the first time. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the camera is to be operated with a spectrograph (such as an Acton Series 2300 spectrograph) on which it has been properly installed (refer to Appendix D for instructions for mounting a spectrograph adapter to the PIXIS). A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

### **Caution**

***Overexposure Protection:*** Cameras that are exposed to room light or other continuous light sources will quickly become saturated. If the camera is mounted to a spectrograph, close the entrance slit of the spectrograph to reduce the incident light.

### **Assumptions**

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapter 4.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is being operated in spectroscopy mode.
5. The PIXIS does not have an internal shutter.

- The spectrograph has an entrance slit shutter that is being controlled by the PIXIS via the **Shutter** connector.

**Caution**

If the PIXIS has an internal shutter, **DO NOT USE** the **Shutter** connector to drive a spectrograph entrance slit shutter. If both the camera and the spectrograph have shutters, the entrance slit shutter will have to be removed or a Princeton Instruments SHC-EXT Shutter Control Box may be used to control the opening and closing of the entrance slit shutter. See the spectrograph manual.

**Getting Started**

- Set the spectrograph entrance slit width to minimum (10  $\mu\text{m}$  if possible).
- Power ON the spectrograph (i.e., switch the power supply ON).
- Mount a light source at the spectrograph entrance slit.
- Mount the camera to the spectrograph exit port.
- Connect the shutter cable between the entrance slit shutter and the PIXIS **Shutter** connector.
  - External Slit Shutter:** A shutter assembly mounted externally to the spectrograph has shutter cable that plugs into the **Shutter** connector.
  - Internal Slit Shutter:** A shutter mounted internally has an external shutter connector in the sidewall of the spectrograph. Connect a shutter cable from the PIXIS **Shutter** connector to that connector.
- Power ON the camera (i.e., switch the power supply ON).
- Turn on the computer power.
- Start the application software.

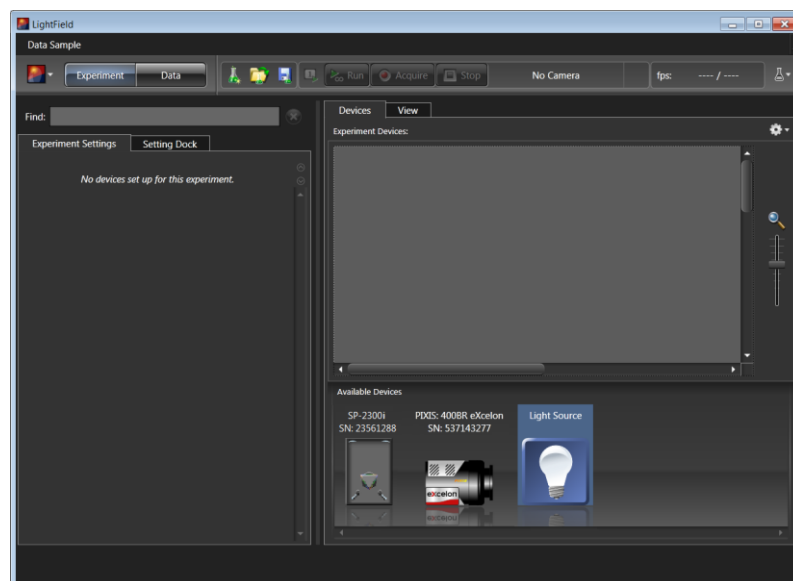
**Setting the Parameters**

Figure 17. Available Devices Area

1. After LightField opens, you should see icons representing your camera and the spectrograph in the **Available Devices** area. In the figure above, the camera is a PIXIS:400BR eXcelon<sup>®</sup> and the spectrograph is an SP-2356.
2. Drag the icons into the **Experiment Devices** area.

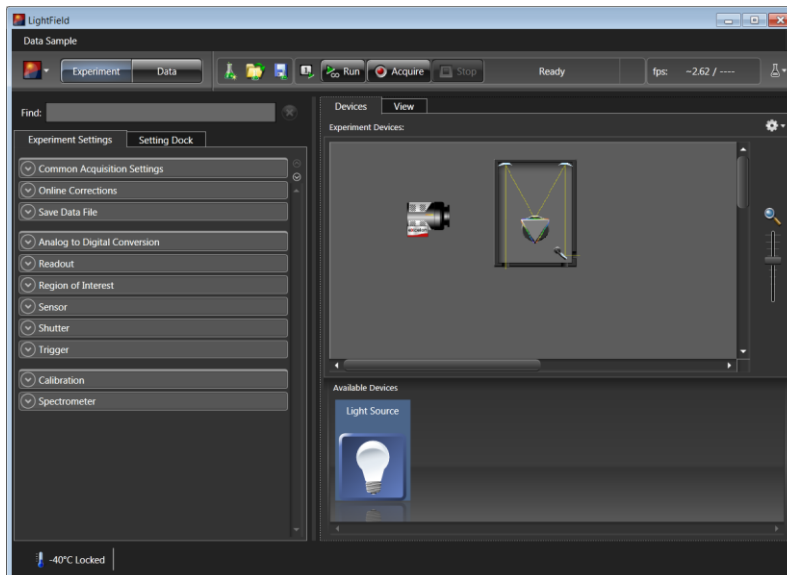


Figure 18. Experiment Devices Area

3. Note that the **Experiment Settings** stack on the left now displays several expanders. Because this is a new experiment, the default settings for the camera will be active. The **Status** bar (at the bottom of the window) displays an icon for temperature status.

Temperature status reports the current temperature and whether the set temperature has been reached. Clicking on the icon opens the **Sensor** expander where the set temperature can be changed.

4. On the **Shutter** expander, select **Shutter Mode: Normal**.
5. Open the **Spectrometer** expander, select the appropriate grating. In this case, the 300g/mm (Blaze: 750) grating was selected and the center wavelength was set to 500 nm for a mercury lamp. Use 0.0 nm if using a broadband source.

**Hint:** Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrograph. Select 500 nm as the spectral line.

6. Open the **Spectrometer** expander, select the appropriate grating. In this case, the 300g/mm (Blaze: 750) grating was selected and the center wavelength was set to 500 nm for a mercury lamp. Use 0.0 nm if using a broadband source.



### **Confirming the Setup**

1. Turn on the light source at the spectrograph entrance slit.
2. Click on **Run** to begin previewing the data. Depending on the display settings, you should see either a spectral band (image) or a graph. Background noise will decrease as the camera cools to its default temperature.
3. Turn off the light source. The data display should change to a background noise pattern or low intensity graph. If this occurs you have confirmed that light entering the spectrograph is being seen by the camera. Skip Steps 4-5 and continue to the “*Focusing*” topic on page 50.
4. If there is little or no difference between the data displayed when the light source is on or off:
  - a. Verify that the light source has power and is turned on.
  - b. Verify that the entrance slit is open at least 10  $\mu\text{m}$ .
  - c. Check the **Exposure Time (Common Acquisition Settings expander)**.
  - d. Confirm that **Shutter Mode** is set to **Normal (Shutter expander)**.
  - e. Check the shutter cable connections.
  - f. Verify shutter operation. You should hear the shutter open and close while **Run** is active.
    - If you hear a shutter operating and you have done Steps a-e, turn the light source on, wait a minute and then turn the light off while you view the data display. If the problem is fixed, stop acquisition or continue to the “*Focusing*” topic on page 40 ; otherwise, **stop data acquisition** and continue to Step g.
    - If you do not hear a shutter operating and you have done Steps a-e, **stop data acquisition** and continue to Step g.
  - g. Make sure the spectrograph has an entrance slit shutter. An externally mounted shutter is easily confirmed. Verifying an internally mounted shutter requires access to the inside of the spectrograph: refer to the spectrograph manual for instructions.
  - h. Check to see if the PIXIS has a shutter. Loosen and remove the camera from the spectrograph. If you see the CCD when you look into the front of the camera, the camera does not have an internal shutter. Re-mount the camera to the spectrograph.
  - i. If the camera and spectrograph both have shutters, permanent damage to the shutter driver may occur. You can either disconnect and remove the entrance slit shutter or control it via a Princeton Instruments SHC-EXT Control Box. To disconnect and remove an entrance slit shutter:
    - **External Slit Shutter:** Disconnect the shutter cable and remove the shutter assembly from the spectrograph entrance port.
    - **Internal Slit Shutter:** Disconnect the shutter cable. Removing an internally mounted shutter requires access to the inside of the spectrograph: refer to the spectrograph manual for removal instructions.
5. If you need more help, contact Customer Support. See page 126 for contact information.

## Focusing

The detector mounting hardware provides two degrees of freedom: **focus** and **rotation**. In this context, focus means to physically move the detector back and forth through the focal plane of the spectrograph. The approach taken is to slowly move the detector in and out of focus and adjusting for optimum while watching a live display on the monitor, followed by rotating the detector and again adjusting for optimum. The following procedure, which describes the focusing operation with an Acton SP-2300i spectrograph, can be easily adapted to other spectrographs. For IsoPlane SCT-320 related focusing information, see “*IsoPlane SCT-320 Spectrograph*” on page 53.

### Acton Series Spectrograph

1. Click on the **View** tab, just above **Experiment Devices**, to change to the display area.

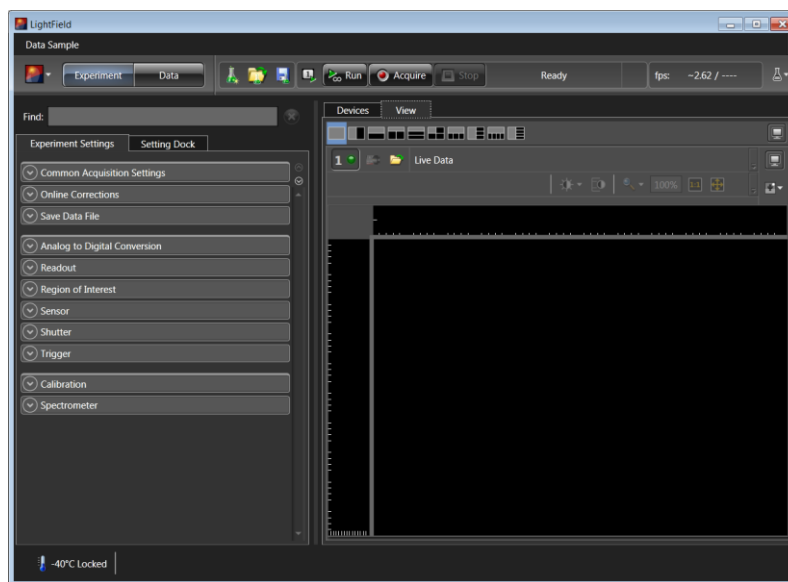


Figure 19. View Area

2. Mount a light source such as a mercury pen-ray type in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.
3. Open the **Spectrometer** expander, select the grating and set the center wavelength to 500 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

**Hint:** Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrograph. Select 500 nm as the spectral line.

4. Set the slit to 10  $\mu\text{m}$ . *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
5. Wait until the detector temperature locks at its default temperature.

6. Make sure that the spectroscopy-mount adapter moves freely at the spectrograph.
7. Select **Align Spectrometer...** from the **Experiment Options** menu. Review the displayed information and then click on the Begin button. Typically, this feature creates three 1-row high ROIs (one near the top of the array, one in the middle, and one near the bottom) and begins data acquisition. Data will be continuously acquired and displayed but will not be stored.

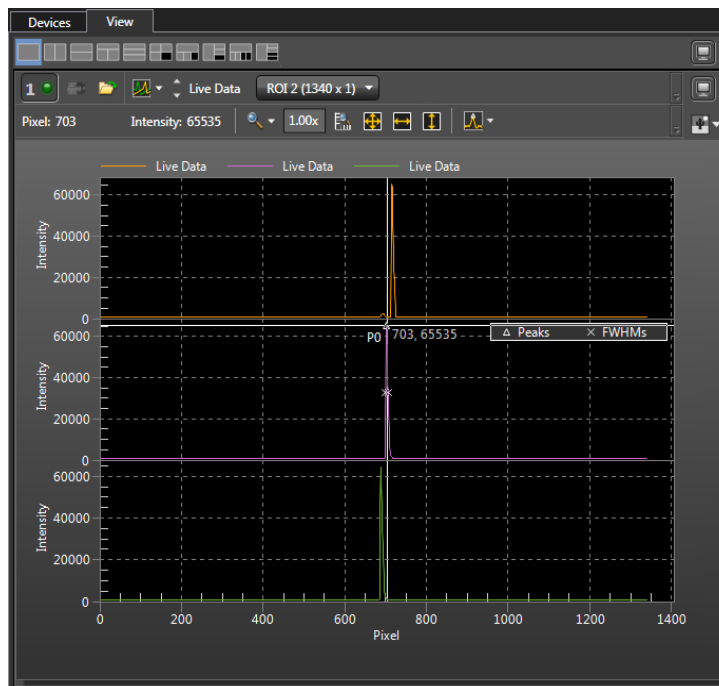


Figure 20. Spectrometer Alignment: Before Rotational Alignment

8. Slowly move the camera in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Leave the camera set for the narrowest achievable line. Note that the Peak Finding function is active for the center graph to allow you to monitor the FWHM information to achieve the narrowest line width.

The way focusing is accomplished depends on the spectrograph, as follows:

- **Long focal-length spectrographs such as the Acton SP-2300:** The mounting adapter includes a tube that slides inside another tube to move the camera in or out as required to achieve optimum focus.
- **Short focal-length spectrographs:** There is generally a focusing mechanism on the spectrograph itself which, when adjusted, will move the optics as required to achieve proper focus.
- **No focusing adjustment:** If there is no focusing adjustment, either provided by the spectrograph or by the mounting hardware, then the only recourse will be to adjust the spectrograph's focusing mirror.

9. Next adjust the rotation. You can do this by rotating the camera while watching a live display of the line (you may need to loosen two setscrews securing the spectrograph adapter). Click on the peak you want to monitor during the rotational alignment. This positions the large cursor to provide a vertical reference line across all of the ROIs.
10. Rotate the camera while watching the live display of the lines until the selected peak is aligned horizontally in all of the ROIs. Tighten the setscrews securing the spectrograph adapter at the spectrograph.

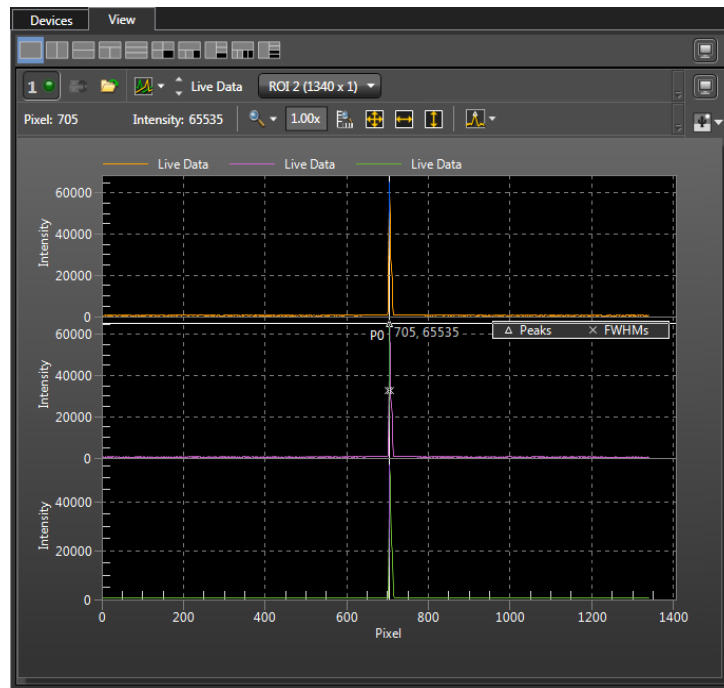


Figure 21. Spectrometer Alignment: After Rotational Alignment

Alternatively, take an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the detector until the line shape on the screen is parallel with the vertical bar.

**Note:** When aligning other accessories, such as fibers, lenses, optical fiber adapters, first align the spectrograph to the slit. Then align the accessory without disturbing the camera position. The procedure is identical to that used to focus the spectrograph (i.e., do the focus and alignment operations while watching a live image).

11. Tighten the spectrograph set screws to secure the spectrograph adapter and stop data acquisition.

### IsoPlane SCT-320 Spectrograph

Because the PIXIS is mounted directly to the mounting plate on the IsoPlane, focusing and alignment is different from the way that focusing and alignment are performed for an Acton Series spectrograph. The following information assumes that you are familiar with the locations of the mounting plate, Micrometer Compartment, and the locking set screw. If not, refer to the IsoPlane manual supplied with the spectrograph.

**Note:** If the PIXIS has an internal shutter, **DO NOT USE** the **Shutter** connector to drive a shutter internal to an IsoPlane. If both the camera and spectrograph have shutters, the IsoPlane shutter will have to be removed or a Princeton Instruments SHC-EXT Shutter Control Box can be used to control the opening and closing of the IsoPlane's internal shutter. See the IsoPlane SCT 320 manual for more information.

1. Mount an Acton light source such as the dual HG/NeAr source in front of the entrance slit of the spectrograph.
2. With the IsoPlane properly connected to the computer, turn the power on, wait for the spectrograph to initialize.
3. With the PIXIS mounted to the spectrograph and connected to the computer, turn on the power and wait for the detector to initialize.
4. Start the application software. Because you are using LightField, you will need to drag the icons for the PIXIS and the IsoPlane into the **Experiment Devices** area.
5. Set the spectrograph to 500 nm if using a mercury source or to 0.0 nm if using a broadband source.
6. Remove the cover from the Micrometer Compartment.
7. Using a 3/32" hex wrench, loosen the locking set screw.
8. Wait until the detector temperature locks at its default temperature.
9. Click on **Run** and while continuously acquiring data, adjust the micrometer until you maximize the intensity level of a selected peak or peaks.
10. Tighten down the locking set screw.
11. Place the Micrometer Cover on the spectrograph. Replace and tighten all of the cover screws.
12. Next adjust the rotation. First, use a 9/64" hex wrench to loosen the four screws at the corners of the detector mounting plate. While watching a live display of the spectrum, choose a peak to monitor and then rotate the detector (up to 4 degrees of rotation are possible). The peak will go from broad to narrow and back to broad. Leave the detector rotation set for the narrowest achievable peak.

**Note:** With LightField, you can use the **Align Spectrometer** function.

Alternatively, you can acquire an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the detector until the line shape on the screen is parallel with the vertical bar.

13. After completing the rotational alignment, re-tighten the four mounting plate screws and stop acquisition.

## Exposure and Signal

### Introduction

The following topics address factors that can affect the signal acquired on the CCD array. These factors include array architecture, exposure time, CCD temperature, dark charge, and saturation.

### CCD Array Architecture

Charge coupled devices (CCDs) can be roughly thought of as a two-dimensional grid of individual photodiodes (called pixels), each connected to its own charge storage “well.” Each pixel senses the intensity of light falling on its collection area, and stores a proportional amount of charge in its associated “well.” Once charge accumulates for the specified exposure time (set in the software), the pixels are read out serially.

CCD arrays perform three essential functions: photons are transduced to electrons, integrated and stored, and finally read out. CCDs are very compact and rugged and can withstand direct exposure to relatively high light levels, magnetic fields, and RF radiation. They are easily cooled and can be precisely thermostated to within a few tens of millidegrees.

### Exposure with a Mechanical Shutter

For some CCD arrays, the PIXIS uses a mechanical shutter to control exposure of the CCD. The diagram in Figure 22 shows how the exposure period is measured. The NOT SCAN {Not Reading Out} signal at the **LOGIC OUT** connector on the back of the PIXIS can be used to monitor the exposure and readout cycle ( $t_R$ ). This signal is also shown in Figure 22. The value of  $t_c$  is shutter type dependent, and will be configured automatically for PIXIS cameras shipped with an internal shutter.

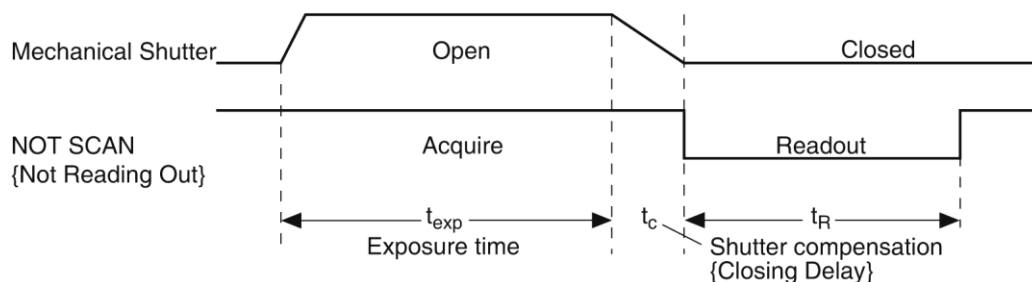


Figure 22. Exposure of the CCD with Shutter Compensation

Note that NOT SCAN {Not Reading Out} is low during readout, high during exposure, and high during shutter compensation time.

Since most shutters behave like an iris, the opening and closing of the shutter will cause the center of the CCD to be exposed slightly longer than the edges. It is important to realize this physical limitation, particularly when using short exposures.

### Caution

A shutter can become overheated when short, rapidly repeated exposures are used or if the shutter is held open for an extended period of time. Newer versions of the WinView/WinSpec software and camera hardware monitor the temperature of **45 mm internal shutters** to prevent overheating conditions. ***The temperature of external shutters is NOT monitored!***

### **Continuous Exposure (No Shuttering)**

For full-frame imaging CCDs, the standard PIXIS camera for imaging is equipped with an integral shutter. However, inasmuch as it is possible to order the camera without a shutter, the following general discussion of unshuttered operation is provided.

Slow scan scientific cameras require a shutter to prevent "smearing" of features during readout. This is because during readout, charge is moved horizontally or vertically across the surface of the CCD. If light is falling on the CCD during readout then charge will continue to accumulate, blurring the image along one direction only.

Because spectroscopy CCDs typically have their parallel shifting aligned vertically (perpendicular to the spectrum), smearing does not affect the spectral resolution, only the intensity level of the spectral features. When vertically binned, the readout generally takes a few milliseconds to tens of milliseconds. In experiments where the exposure time is much larger than the readout time, the smearing due to readout is insignificant, and the CCD can be operated without a shutter with very little loss of performance.

If the CCD is set up for imaging mode (the WinSpec Imaging option has been installed and is selected on the **Experiment Setup|ROI Setup** tab), smearing may be more of a factor. In this case, controlling the light source so no light falls on the CCD during readout would minimize any smearing. If the light source can be controlled electronically via the output of the **LOGIC OUT** connector, the CCD can be read out in darkness.

### **Exposure Time**

Exposure time, which is set on the **Experiment Setup|Main** tab { **Common Acquisition Settings** expander }, is the time between start acquisition and stop acquisition commands sent by the application software to the camera. In combination with triggers, these commands control when continuous cleaning of the CCD stops and when the accumulated signal will be readout. The continuous cleaning prevents buildup of dark current and unwanted signal before the start of the exposure time. At the end of the exposure time, the CCD is readout and cleaning starts again.

Because some PIXIS cameras do not incorporate an internal shutter, some signal may accumulate on the array while it is being readout. This continuous exposure of the array during readout may result in some smearing. However, exposures that are significantly longer than the readout time can be performed without a shutter, as the amount of smearing will be low.

If smearing or other factors require a shutter, the **NOT SCAN {Not Reading Out}** or the **SHUTTER {Shutter Open}** signal at the **LOGIC OUT** connector (on the rear of the PIXIS) can be used to control a customer-supplied external shutter. By using one of the signals to synchronize the shutter operation with exposure, the CCD can be read out in darkness.

### **CCD Temperature**

As stated before, lowering the temperature of the CCD will generally enhance the quality of the acquired signal. When WinX is the controlling software, temperature control is done via the **Detector Temperature** dialog (see Figure 23) accessed from the **Setup** menu. When LightField is being used, temperature control is done on the **Sensor** expander.

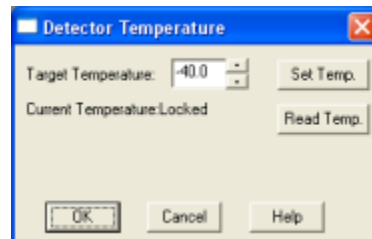


Figure 23. WinX  
Detector Temperature dialog

Once the target array temperature {Temperature Setpoint} has been set, the software controls the camera's cooling circuits to reach set array temperature. On reaching that temperature, the control loop locks to that temperature for stable and reproducible performance. When temperature lock has been reached (temperature within 0.05°C of set value), the current temperature is **Locked**. The on-screen indication allows easy verification of temperature lock.

The time required to achieve lock can vary over a considerable range, depending on such factors as the camera type, CCD array type, ambient temperature, etc. Once lock occurs, it is okay to begin focusing. However, you should wait an additional twenty minutes before taking quantitative data so that the system has time to achieve optimum thermal stability.

The deepest operating temperature for a system depends on the CCD array size and packaging. Refer to Table 5, on page 93, for typical deepest cooling temperatures.

**Note:** In WinX, the Detector Temperature dialog will not display temperature information while you are acquiring data.

### **Dark Charge**

Dark charge (or dark current) is the thermally induced buildup of charge in the CCD over time. The statistical noise associated with this charge is known as dark noise. Dark charge values vary widely from one CCD array to another and are exponentially temperature dependent. In the case of cameras with MPP type arrays, the average dark charge is extremely small. However, the dark-charge distribution is such that a significant number of pixels may exhibit a much higher dark charge, limiting the maximum practical exposure. Dark charge effect is more pronounced in the case of cameras having a non-MPP array (such as deep-depletion devices).

With the light into the camera completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger and less uniform this background will appear. Thus, to minimize dark-charge effects, you should operate with the lowest CCD temperature possible.

**Note:** Do not be concerned about either the DC level of this background. What you see is not noise. It is a fully subtractable bias pattern. Simply acquire and save a dark charge "background image" under conditions identical to those used to acquire the "actual" image. Subtracting the background image from the actual image will significantly reduce dark-charge effects.

### **WARNING!**

If you observe a sudden change in the baseline signal, there may be excessive humidity in the camera vacuum enclosure. Turn off the camera and contact Princeton Instruments Customer Support. See page 126 for contact information.

### **Saturation**

When signal levels in some part of the image are very high, charge generated in one pixel may exceed the "well capacity" of the pixel, spilling over into adjacent pixels in a process called "blooming." In this case a shorter exposure is advisable, with signal averaging to enhance S/N (Signal-to-Noise ratio) accomplished through the software.



For signal levels low enough to be readout-noise limited, longer exposure times, and therefore longer signal accumulation in the CCD, will improve the S/N ratio approximately linearly with the length of exposure time. There is, however, a maximum time limit for on-chip accumulation, determined by either the saturation of the CCD by the signal or the loss of dynamic range due to the buildup of dark charge in the pixels.

## Readout

### Introduction

After the exposure time has elapsed, the charge accumulated in the array pixels needs to be read out of the array, converted from electrons to digital format, and transmitted to the application software where it can be displayed and/or stored. Readout begins by moving charge from the CCD image area to the shift register. The charge in the shift register pixels, which typically have twice the capacity of the image pixels, is then shifted into the output node and then to the output amplifier where the electrons are grouped as electrons/count. This result leaves the CCD and goes to the preamplifier where gain is applied.

WinX and LightField allow you to specify the type of readout (full frame or binned), the output amplifier, and the gain (the number of electrons required to generate an ADU).

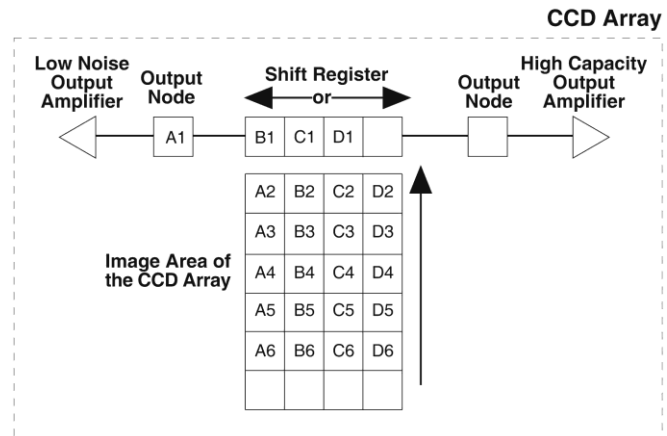


Figure 24. Array Terms for a CCD with a Dual Output Amplifier

### Full Frame Readout

The upper left drawing in Figure 25 represents a CCD after exposure but before the beginning of readout. The capital letters represent different amounts of charge, including both signal and dark charge. This section explains readout at full resolution, where every pixel is digitized separately.

**Note:** With PIXIS cameras you have a choice of amplifier (low noise or high capacity). Depending on the selected amplifier, the shift register may be read out to the right or to the left. For simplicity this drawing shows the readout to the left.

Readout of the CCD begins with the simultaneous shifting of all pixels one row toward the "shift register," in this case the row on the top. The shift register is a single line of pixels along the edge of the CCD, not sensitive to light and used for readout only. Typically the shift register pixels hold twice as much charge as the pixels in the imaging area of the CCD.

After the first row is moved into the shift register, the charge now in the shift register is shifted toward the output node, located at one end of the shift register. As each value is "emptied" into this node it is digitized. Only after all pixels in the first row are digitized is the second row moved into the shift register. The order of shifting in our example is therefore A1, B1, C1, D1, A2, B2, C2, D2, A3....

After charge is shifted out of each pixel the remaining charge is zero, meaning that the array is immediately ready for the next exposure.

Below are the equations that determine the rate at which the CCD is read out.

The time needed to take a full frame at full resolution is:

$$t_R + t_{\text{exp}} + t_c \quad (1)$$

where

$t_R$  is the CCD readout time,

$t_{\text{exp}}$  is the exposure time, and

$t_c$  is the shutter compensation time.

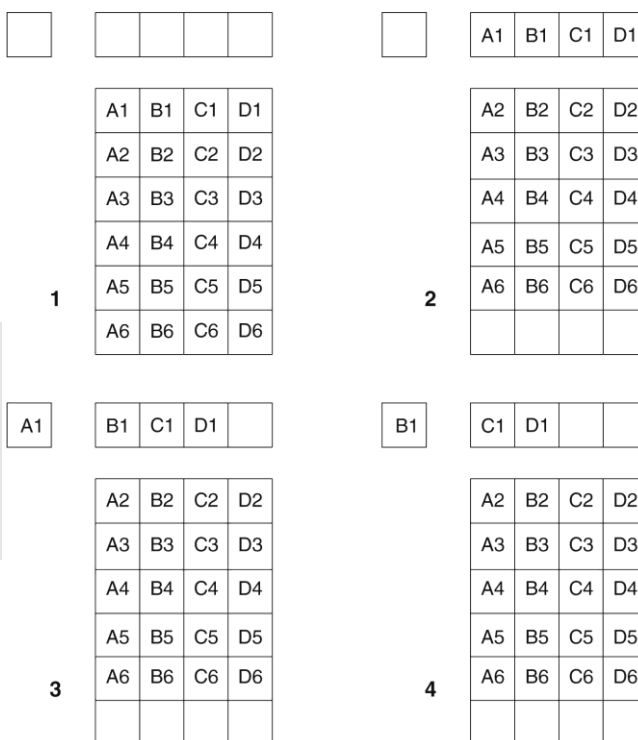


Figure 25. Full Frame at Full Resolution

The readout time is approximately given by:

$$t_R = [N_x \cdot N_y (t_{sr} + t_v)] + (N_x \cdot t_i) \quad (2)$$

where

$N_x$  is the smaller dimension of the CCD

$N_y$  is the larger dimension of the CCD

$t_{sr}$  is the time needed to shift one pixel out of the shift register

$t_v$  is the time needed to digitize a pixel

$t_i$  is the time needed to shift one line into the shift register

A subsection of the CCD can be read out at full resolution, sometimes dramatically increasing the readout rate while retaining the highest resolution in the region of interest (ROI). To approximate the readout rate of an ROI, in Equation 2 substitute the x and y dimensions of the ROI in place of the dimensions of the full CCD. Some overhead time, however, is required to read out and discard the unwanted pixels.

### ***Binning***

Binning is the process of adding the data from adjacent pixels together to form a single pixel (sometimes called a super pixel), and it can be accomplished in either hardware or software. Rectangular groups of pixels of any size may be binned together, subject to some hardware and software limitations.

### ***Hardware Binning***

Hardware binning is performed on the CCD array *before* the signal is read out of the output amplifier. For signal levels that are readout noise limited this method improves S/N ratio linearly with the number of pixels grouped together. For signals large enough to render the camera photon shot noise limited, the S/N ratio improvement is roughly proportional to the square-root of the number of pixels binned.

Binning also reduces readout time and the burden on computer memory, but at the expense of resolution. Since shift register pixels typically hold only twice as much charge as image

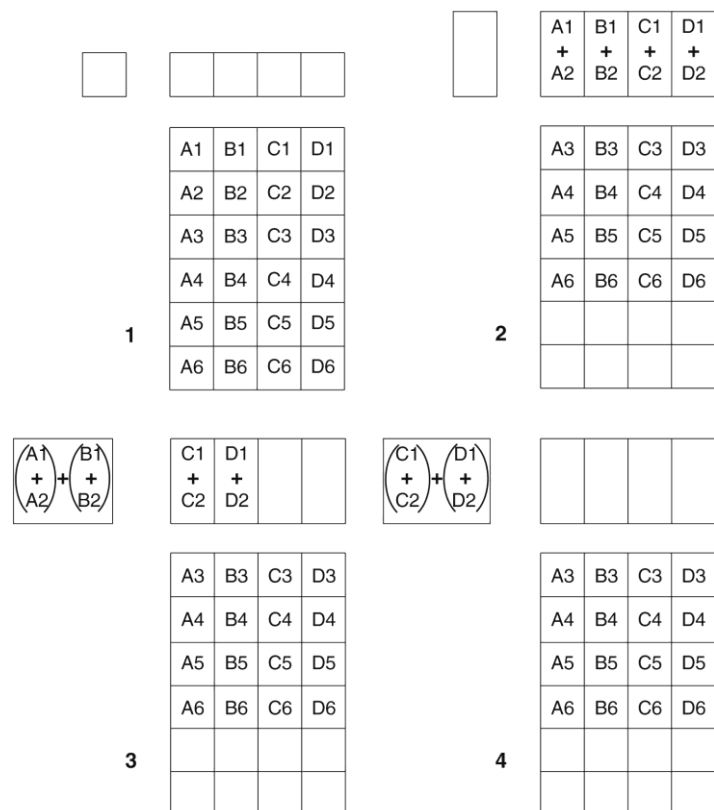


Figure 26.  $2 \times 2$  Binning

pixels, the binning of large sections may result in saturation and “blooming”, or spilling of charge back into the image area.

Figure 26 shows an example of  $2 \times 2$  binning. Each pixel of the image displayed by the software represents 4 pixels of the CCD array. Rectangular bins of any size are possible. Binning also reduces readout time and the burden on computer memory, but at the expense of resolution. Since shift register pixels typically hold only twice as much charge as image pixels, the binning of large sections may result in saturation and “blooming”, or spilling of charge back into the image area.

The readout rate for  $n \times n$  binning is approximated using a more general version of the full resolution equation. The modified equation is:

$$t_R = \left[ N_x \cdot N_y \cdot \left( \frac{t_{sr}}{n} + \frac{t_v}{n^2} \right) \right] + (N_x \cdot t_i) \quad (3)$$

### **Software Binning**

One limitation of hardware binning is that the shift register pixels and the output node are typically only 2-3 times the size of imaging pixels. Consequently, if the total charge binned together exceeds the capacity of the shift register or output node, the data will be corrupted.

This restriction strongly limits the number of pixels that may be binned in cases where there is a small signal superimposed on a large background, such as signals with a large fluorescence. Ideally, one would like to bin many pixels to increase the S/N ratio of the weak peaks but this cannot be done because the fluorescence would quickly saturate the CCD.

The solution is to perform the binning in software. Limited hardware binning may be used when reading out the CCD. Additional binning is accomplished in software, producing a result that represents many more photons than was possible using hardware binning.

Software averaging can improve the S/N ratio by as much as the square-root of the number of scans. Unfortunately, with a high number of scans, i.e., above 100, camera 1/f noise may reduce the actual S/N ratio to slightly below this theoretical value. Also, if the light source used is photon-flicker limited rather than photon shot-noise limited, this theoretical signal improvement cannot be fully realized. Again, background subtraction from the raw data is necessary.

This technique is also useful in high light level experiments, where the camera is again photon shot-noise limited. Summing multiple pixels in software corresponds to collecting more photons, and results in a better S/N ratio in the measurement.

### **Array Orientation**

For square format CCDs (for example,  $512 \times 512$ B or  $1024 \times 1024$ F/B) you may orient the CCD to achieve binning along either direction of the CCD.

- Binning along columns provides maximum scan rate.
- Binning along the rows minimizes crosstalk and is therefore better for multi-spectral applications.

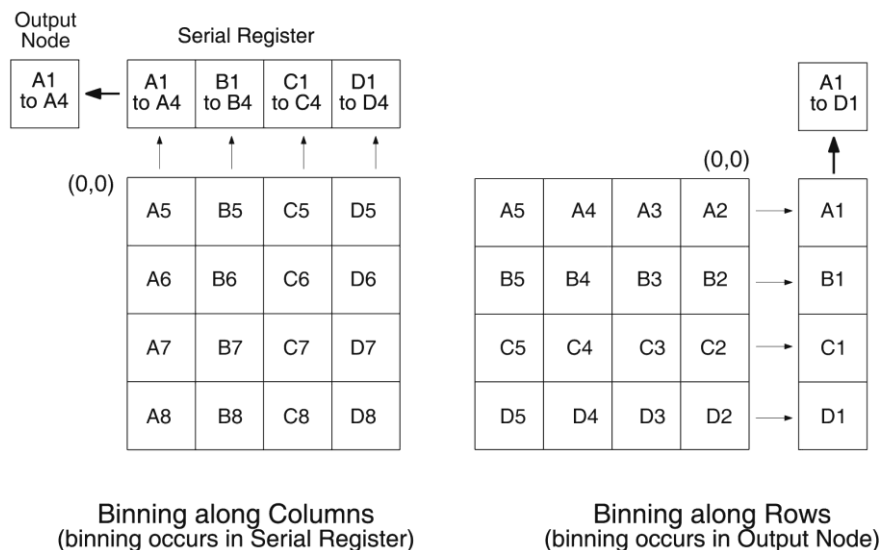


Figure 27. Binning and Array Orientation

**Note:** You can easily switch between these orientations by rotating the camera 90° and changing the binning parameters in the application software.

### Output Amplifier {Quality} Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Although Figure 24 shows an array with dual output nodes and amplifiers (one set at each end of the shift register), some PIXIS systems are available with a single output node and amplifier. If your system has dual output amplifiers, you can choose the output amplifier to be used (High Capacity or Low Noise) via the **Acquisition|Experiment Setup...|ADC tab {Quality on the Analog to Digital Conversion expander}**:

- **High Capacity amplifier:** Provides a spectrometric well capacity that is approximately 3 times the well capacity for the Low Noise amplifier selection. High Capacity is suitable when you have intense light signals or signals with high dynamic range.
- **Low Noise amplifier:** Provides the highest sensitivity performance and is suitable when you have weak signals.

**Note:** The choice of output amplifier {Quality} and controller gain {Analog Gain} setting should be considered together for the best signal capture. Examples of the interaction of output amplifier and controller gain selections are shown in Table 2.

### Controller Gain

Controller gain (a function of the preamplifier) is software-selectable and is used to change the relationship between the number of electrons acquired on the CCD and the Analog-to-Digital Units (ADUs or counts) generated. Selecting the amount of gain is done on the **Acquisition|Experiment Setup...|ADC** tab { **Analog to Digital Conversion** expander}. The choices are **1 {Low}**, **2 {Medium}**, and **3 {High}**. Users who measure high-level signals may wish to select **Low** to allow digitization of larger signals. **Medium** is suitable for experiments within the mid-level intensity range. Users who consistently measure low-level signals may wish to select **High**, which requires fewer electrons to generate an ADU and reduces some sources of noise.

The "Certificate of Performance" supplied with the camera lists the measured gain values at all settings.

**Example:** The following descriptions assume the **Low Noise** Readout Port has been selected and that the actual incoming light level is identical in all three instances. *The numbers used illustrate the effect of changing a controller gain setting and may not reflect actual performance: gain at the 1, 2, and 3 settings depends on the CCD installed.*

Readout Port {Quality}	Controller Gain {Analog Gain} Selection		
	1 {Low}	2 {Medium}	3 {High}
Low Noise	4 e <sup>-</sup> /count	2 e <sup>-</sup> /count	1 e <sup>-</sup> /count
High Capacity	16 e <sup>-</sup> /count	8 e <sup>-</sup> /count	4 e <sup>-</sup> /count

Table 2. Example of Controller Gain {Analog Gain} vs. Readout Port

**1 {Low}** requires four electrons to generate one ADU. Strong signals can be acquired without flooding the CCD array. If the gain is set to **Low** and the images or spectra appear weak, you may want to change the gain setting to **Medium** or **High**.

**2 {Medium}** requires two electrons to generate one ADU. If the gain is set to **Medium** and the images or spectra do not appear to take up the full dynamic range of the CCD array, you may want to change the gain setting to **High**. If the CCD array appears to be flooded with light, you may want to change the setting to **Low**.

**3 {High}** requires one electron to generate one ADU and some noise sources are reduced. Because fewer electrons are needed to generate an ADU, weaker signals can be more readily detected. Lower noise further enhances the ability to acquire weak signals. If the CCD array appears to be flooded with light, you may want to change the setting to **Medium** or **Low**.

## Digitization (Rate)

### **Introduction**

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts that analog information (continuous amplitudes) into a digital data (quantified, discrete steps) that can be read, displayed, and stored by the application software. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software (see "**Readout**", page 57).

Factors associated with digitization include the digitization rate and baseline offset. The speed at which digitization occurs is software-selectable but baseline offset is factory-set. These factors are discussed in the following paragraphs.

### **Digitization Rate {Speed}**

PIXIS cameras incorporate dual digitization (100 kHz/2 MHz), which means that you have a choice of how quickly the data will be digitized. Dual digitization provides optimum signal-to-noise ratios at both readout speeds. Because the readout noise of CCD arrays increases with the readout rate, it is sometimes necessary to trade off readout speed for high dynamic range. The 2 MHz conversion speed is used for the fastest possible data collection and the 100 kHz conversion speed is used where noise performance is the paramount concern. Switching between the conversion speeds is completely under software control for total experiment automation.

**Note:** In WinX, the ADC rate can be changed on the **Experiment Setup|ADC** tab. In LightField, the speed is changed on the **Analog-Digital Conversion** expander.

### **ADC Offset (Bias)**

With the camera completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger this background will appear. To minimize the amount of this signal that gets digitized, the baseline has been offset by adding a voltage to the signal to bring the A/D output to a non-zero value, typically 500-600 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the A/D "0" value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 (16-bit A/D) to a value in the range of 500-600 counts lower.

#### **Notes:**

1. It is important to note that the bias level is not noise. It is a fully subtractable readout pattern. Every device has been thoroughly tested to ensure its compliance with Princeton Instruments' demanding specifications.
2. The ADC Offset is pre-set at the factory and is not user-changeable.

### **WARNING!**

If you observe a sudden change in the baseline signal, there may be excessive humidity in the camera vacuum enclosure. Turn off the camera and contact Princeton Instruments Customer Support. See page 126 for contact information.

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## Advanced Topics

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### Introduction

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization. Synchronization is set up on the **Experiment Setup|Timing** tab in WinX and on the **Shutter** and **Trigger** expanders in LightField. With the exception of Edge Trigger, the topics are addressed in order of their appearance on the Timing tab.

*“Timing Modes”*, the first topic, discusses Timing Modes {Trigger Response}, Shutter Control {Shutter Mode}, and Edge Trigger. Also included under this topic is a discussion of the **EXT SYNC** connector, the input connector for a trigger pulse.

*“Fast and Safe Modes”*, the second topic, discusses the Fast and the Safe modes. Fast is used for real-time data acquisition. Safe is used in WinX when coordinating acquisition with external devices or when the computer speed is not fast enough to keep pace with the acquisition rate.

*“Logic Out Control”* discusses the **EXT SYNC** and **LOGIC OUT** output connectors on the rear of the PIXIS. The levels at this connector can be used to monitor camera operation or synchronize external equipment.

*“Kinetics Mode”* describes how to set up and acquire data with the Kinetics Mode (a WinX option, standard with LightField), which allows full-frame CCDs to take time-resolved images/spectra. Note that full-frame CCDs require mechanical or optical masking of the CCD array.

*“Custom Modes”*, the final topic, discusses Custom Chip {Custom Sensor} and Custom Timing modes. These modes allow you to specify an active sub-area of the CCD array and/or a faster vertical shift rate for the purpose of increased frame rate (pixels outside of the area are not read). Custom Chip {Custom Sensor} mode requires mechanical or optical masking of the array to prevent smearing.

## Timing Modes

### Overview

The basic PIXIS timing modes are Free Run {No Response}, External Sync {Readout Per Trigger}, and External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}. These timing modes are combined with the Shutter options to provide the widest variety of timing modes for precision experiment synchronization.

Mode	Shutter Condition
Free Run {No Response}	Normal
External Sync {Readout Per Trigger}	Normal
External Sync {Readout Per Trigger}	PreOpen {Open Before Trigger}
External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}	Normal
External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger}	PreOpen {Open Before Trigger}

Table 3. Camera Timing Modes

The shutter options available include Normal, PreOpen {Open Before Trigger}, Disable Opened {Always Open} or Disable Closed {Always Closed}. Disable simply means that the shutter will not operate during the experiment. Disable closed {Always Closed} is useful for making dark charge measurements. PreOpen {Open Before Trigger}, available in the External Sync {Readout Per Trigger} and External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger} modes, opens the shutter as soon as the PIXIS is ready to receive an External Sync pulse. This is required if the time between the External Sync pulse and the event is less than a few milliseconds, the time it takes the shutter to open.

The shutter timing is shown in the timing diagrams that follow. Except for Free Run, where the modes of shutter operation are identical, both Normal and PreOpen lines are shown in the timing diagrams and flow chart.

The timing diagrams are labeled indicating the exposure time ( $t_{exp}$ ), shutter compensation time ( $t_c$ ), and readout time ( $t_R$ ). These parameters are discussed in more detail in Chapter 5. Note that if there is no shutter selected in the software, the shutter compensation time (the time required to close a mechanical shutter) will be approximately 0 ms.

### Free Run {No Response}

In the Free Run {No Response} mode the camera does not synchronize with the experiment in any way. The shutter opens as soon as the previous readout is complete, and remains open for the exposure time,  $t_{exp}$ . Any External Sync signals are ignored. This mode is useful for experiments with a constant light source, such as a CW laser or a DC lamp.

Other experiments that can utilize this mode are high repetition studies, where the number of shots that occur during a single shutter cycle is so large that it appears to be continuous illumination.

Other experimental equipment can be synchronized to the camera by using the software-selectable output signal **SHUTTER {Shutter Open}** or **NOT SCAN {Not Reading Out}** on the **Hardware Setup|Controller Camera** tab {Trigger expander} from the **LOGIC OUT** connector. Shutter operation and the NOT SCAN {Not Reading Out} output signal are shown in Figure 29.

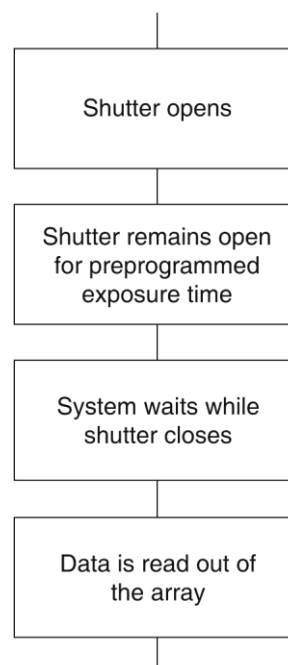


Figure 28. Free Run {No Response} Timing Chart, part of the chart in Figure 36

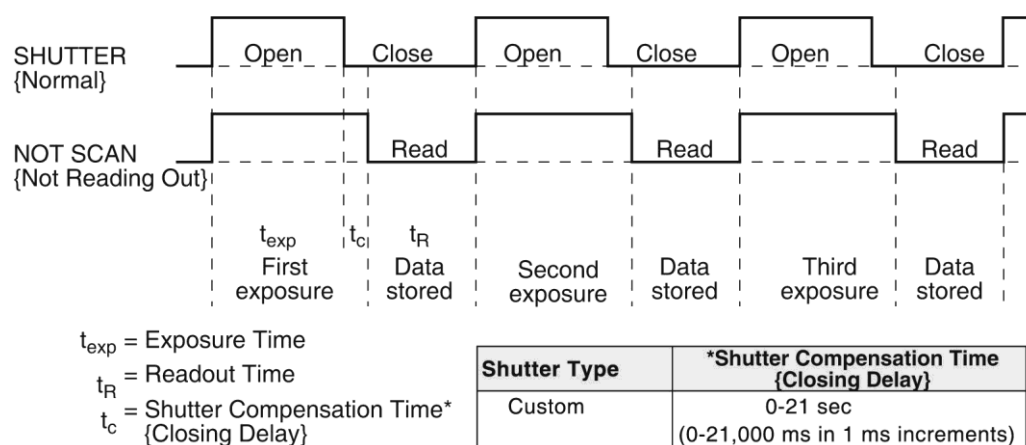


Figure 29. Free Run {No Response} Timing Diagram

### External Sync {Readout Per Trigger}

In this mode all exposures are synchronized to an external source. As shown in the flow chart, Figure 30, this mode can be used in combination with Normal or PreOpen {Open Before Trigger} shutter operation. In Normal Shutter {Normal} mode, the camera waits for an External Sync pulse and then opens the shutter for the programmed exposure period. As soon as the exposure is complete, the shutter closes and the CCD array is read out. The shutter requires up to 8 ms or more to open completely, depending on the shutter model.

External synchronization depends on an edge trigger (negative- or positive-going) which must be supplied to the **EXT SYNC** connector on the back of the camera. The type of edge must be identified in the application software to ensure that the shutter opening is initiated by the correct edge (in WinX, this is done on the **Experiment Setup|Timing** tab, in LightField on the **Trigger** expander). Since the shutter requires at least 8 ms to fully open, the External Sync pulse provided by the experiment must precede the actual signal by at least that much time. If not, the shutter will not be open for the duration of the entire signal, or the signal may be missed completely.

Also, since the amount of time from initialization of the experiment to the first External Sync pulse is not fixed, an accurate background subtraction may not be possible for the first readout. In multiple-shot experiments this is easily overcome by simply discarding the first frame.

In the PreOpen Shutter {Open Before Trigger} mode, on the other hand, shutter operation is only partially synchronized to the experiment. As soon as the camera is ready to collect data, the shutter opens. Upon arrival of the first External Sync pulse at the **EXT SYNC** connector, the shutter remains open for the specified exposure period, closes, and the CCD is read out. As soon as readout is complete, the shutter reopens and waits for the next frame.

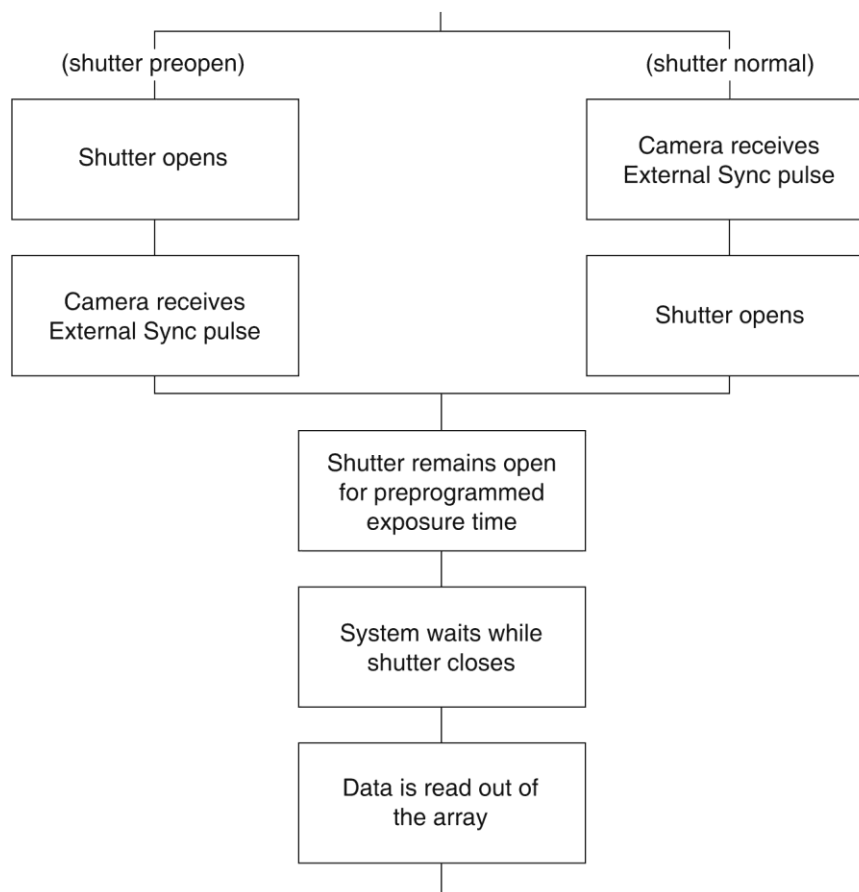


Figure 30. Chart Showing Two External Sync Timing Options

The PreOpen {Open Before Trigger} mode is useful in cases where an External Sync pulse cannot be provided 8 ms or ~ 20 ms (the length of time the 25 mm or 45 mm mechanical shutter takes to open) before the actual signal occurs. Its main drawback is that the CCD is exposed to any ambient light while the shutter is open between frames. If this ambient light is constant, and the triggers occur at regular intervals, this background can also be subtracted, providing that it does not saturate the CCD. As with the Normal Shutter {Normal} mode, accurate background subtraction may not be possible for the first frame.

Also note that, in addition to signal from ambient light, dark charge accumulates during the "wait" time ( $t_w$ ). Any variation in the external sync frequency also affects the amount of dark charge, even if light is not falling on the CCD during this time.

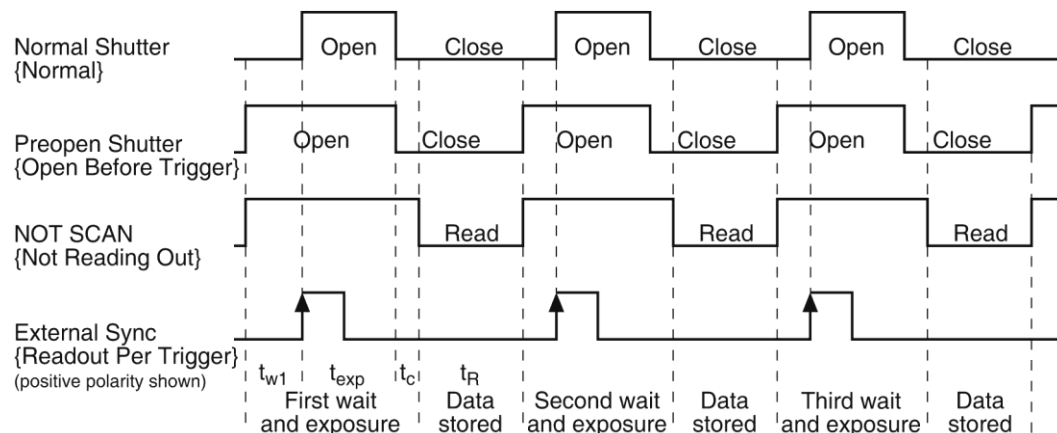


Figure 31. Timing Diagram for External Sync Mode (+ edge trigger)

### **External Sync with Continuous Cleans {Clean Until Trigger} Timing**

Another timing mode available with the PIXIS is called Continuous Cleans {Clean Until Trigger}. In addition to the standard "cleaning" of the array, which occurs after the camera is enabled, this mode will remove any charge from the array until the moment the External Sync pulse is received.

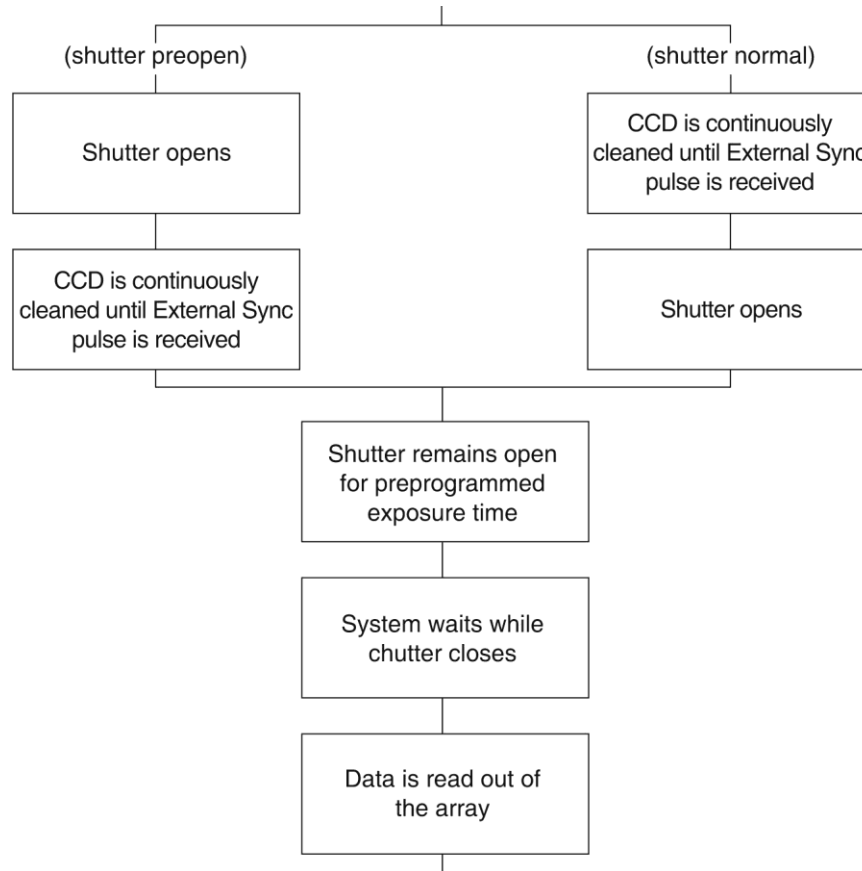


Figure 32. Continuous Cleans {Clean Until Trigger} Flowchart

Once the External Sync pulse is received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins. With Normal Shutter {Normal} operation the shutter is opened for the set exposure time. With PreOpen Shutter {Open Before Trigger} operation the shutter is open during the Continuous Cleaning {Clean Until Trigger}, and once the External Sync pulse is received the shutter remains open for the set exposure time, then closes. If the vertical rows are shifted midway when the External Sync pulse arrives, the pulse is saved until the row shifting is completed, to prevent the CCD from getting "out of step." As expected, the response latency is on the order of one vertical shift time, from 1-30  $\mu$ s depending on the array. This latency does not prevent the incoming signal from being detected, since photo generated electrons are still collected over the entire active area. However, if the signal arrival is coincident with the vertical shifting, image smearing of up to one pixel is possible. The amount of smearing is a function of the signal duration compared to the single vertical shift time.

**Note:** If EXT SYNC is still active (in Figure 33, this means that if it is still HIGH) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

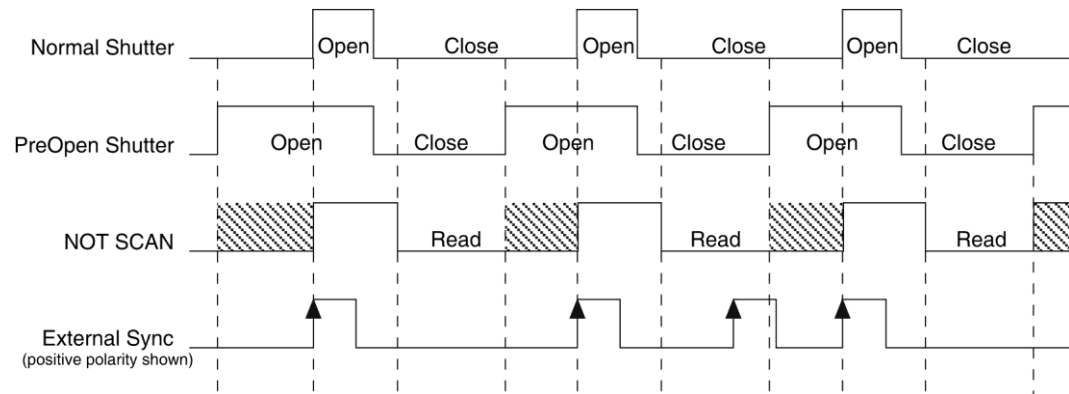


Figure 33. WinX Continuous Cleans Timing Diagram

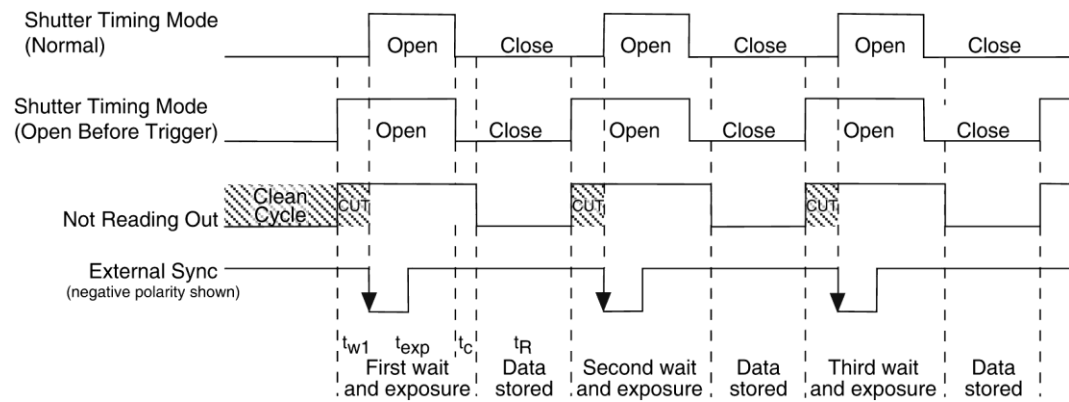


Figure 34. LightField Clean Until Trigger (CUT) Timing Diagram

### EXT SYNC Trigger Input

The selected Timing Mode {Trigger Response} determines how the camera will respond to an External Sync pulse that is input at the **EXT SYNC** connector on the rear of the camera. Things to keep in mind when setting up the External Sync pulse input are:

**Pulse Height:** 0 to +3.3V logic levels (TTL-compatible).

**Pulse Width (trigger edge frequency):**  
The time between trigger edges.

**EXT SYNC Connector Impedance:**  
High impedance.

**Trigger Edge {Polarity}:** Positive or negative polarity must be indicated on the **Experiment Setup|Timing** tab {Trigger expander}.

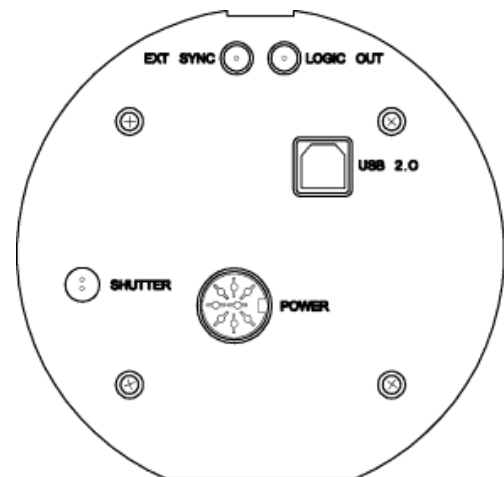


Figure 35. Rear of PIXIS Camera

## Fast and Safe Modes

### *Introduction*

The PIXIS has been designed to allow the greatest possible flexibility when synchronizing data collection with an experiment. The fundamental difference between the Fast and Safe modes is how often the acquisition start and acquisition stop commands are sent by the computer for a data collection sequence. With Safe Mode, the computer sends a start and a stop command for **each frame** of a data sequence. With Fast Mode, the computer sends only one start and one stop command for **each data sequence**. Once the start command is sent, the selected timing mode and the shutter condition determine when charge will be allowed to fall on the CCD array.

In WinX, the choice of **Fast** or the **Safe** data collection is made on the **Experiment Setup|Timing** tab. The flowcharts in Figure 36 show the differences between the two modes. In LightField, **Fast** data collection is always used.

### *Fast Mode (WinX and LightField)*

In Fast operation, the PIXIS runs according to the timing of the experiment, with no interruptions from the computer. Fast operation is primarily for collecting "real-time" sequences of experimental data, where timing is critical and events cannot be missed. Once the PIXIS is sent the start command by the computer, all frames are collected without further intervention from the computer. The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the computer will only display frames when it is not performing other tasks. Image display has a lower priority, so the image on the screen may lag several images behind. A second drawback is that a data overrun may occur if the number of images collected exceeds the amount of allocated RAM or if the computer cannot keep up with the data rate.

**Note:** LightField always uses Fast Mode.

### *Safe Mode (WinX)*

Safe Mode operation is useful when the camera is operated from a slower computer that cannot process the incoming data fast enough. It is also useful when data collection must be coordinated with external devices such as external shutters and filter wheels. As seen in Figure 36, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the camera sends the Stop Acquisition command to the camera, instructing it to stop acquisition. Once that frame is completely processed and displayed, another Start Acquisition command is sent from the computer to the camera, allowing it to take the next frame. Display is therefore, at most, only one frame behind the actual data collection. One disadvantage of the Safe mode is that events may be missed during the experiment, since the PIXIS is disabled for a short time after each frame.

**Note:** When running WinX, Safe Mode must be used whenever the system is set up for the optional Kinetics Readout Mode. See "*Kinetics Mode*" (page 75) for more information about this type of image acquisition and readout.



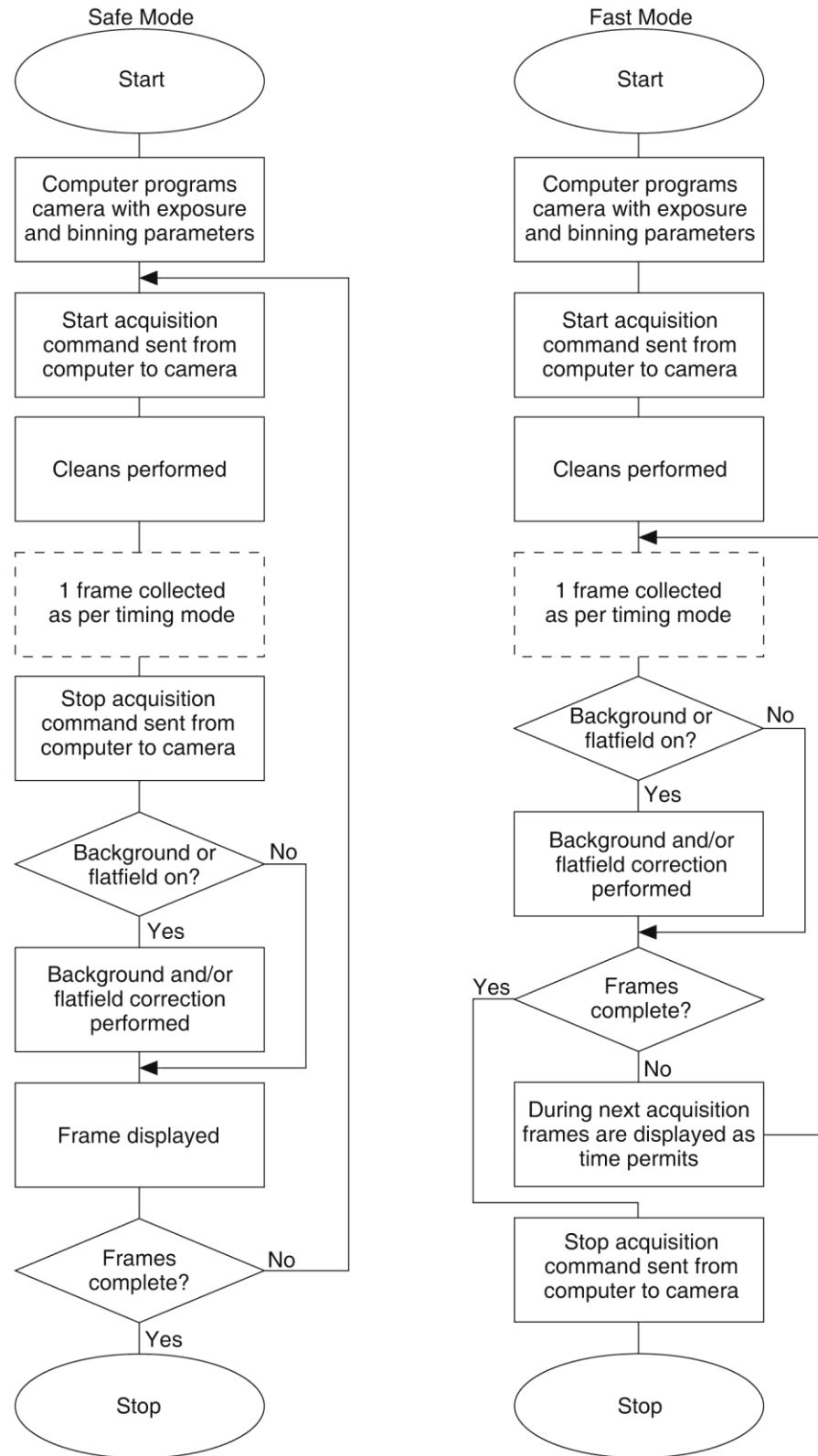


Figure 36. Chart of Safe and Fast Mode Operation

## LOGIC OUT Control

The TTL-compatible logic level output (0 to +3.3 V) from the **LOGIC OUT** connector on the rear panel can be used to monitor camera status and control external devices. By default, the logic output level is high while the action is occurring. The timing of the level changes depends on the output type selected on the **Hardware Setup|Controller/Camera** tab {**Trigger** expander}:

- **NOT SCAN {Not Reading Out}**: It is at a logic low when CCD is being read; otherwise high.
- **SHUTTER {Shutter Open}**: Logic high when the shutter is open. The output precisely brackets shutter-open time (exclusive of shutter compensation,  $t_c$ ) and can be used to control an external shutter or to inhibit a pulser or timing generator.
- **NOT READY {Busy}**: After a start acquisition command, this output changes state on completion of the array cleaning cycles that precede the first exposure. Initially high, it goes low to mark the beginning of the first exposure. In free run operation it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken and then returns high. Figure 37 assumes 3 frames have been programmed.
- **LOGIC 0 {Always Low}**: The level at the connector is low.
- **LOGIC 1 {Always High}**: The level at the connector is high.

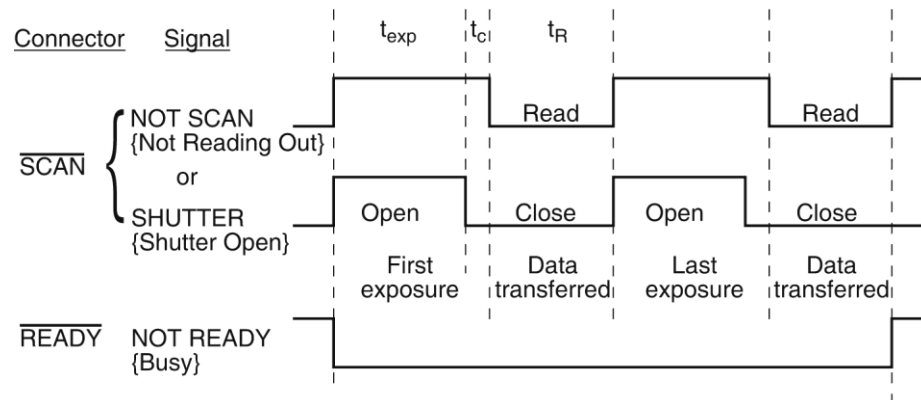


Figure 37. Comparison of NOT SCAN {Not Reading Out}, SHUTTER {Shutter Open}, and NOT READY {Busy} Logic Output Levels

## Kinetics Mode

*In the past, Kinetics Mode was a purchased option for WinView/32. Kinetics Mode is now included in the standard LightField and WinX applications.*

### Introduction

Kinetics mode uses the CCD to expose and store a limited number of images in rapid succession. The time it takes to shift each line (or row) on the CCD is as short as a few hundred nanoseconds to few microseconds, depending on the CCD. Therefore the time between images can be as short as a few microseconds. Kinetics mode allows full frame CCDs to take time-resolved images/spectra. Optical or mechanical masking of the array is required.

**Note:** In WinX, if the Kinetics option has been installed in the PIXIS, this readout mode will be made available when you select the appropriate camera type on the **Hardware Setup** dialog.

Below is a simplified illustration of kinetics mode. Returning to our  $4 \times 6$  CCD example, in this case  $2/3$  of the array is masked, either mechanically or optically. The shutter opens to expose a  $4 \times 2$  region. While the shutter remains open, charge is quickly shifted just under the mask, and the exposure is repeated. After a third image is collected the shutter is closed and the CCD is read out. Since the CCD can be read out slowly, very high dynamic range is achieved. Shifting and readout are shown in Figure 38.

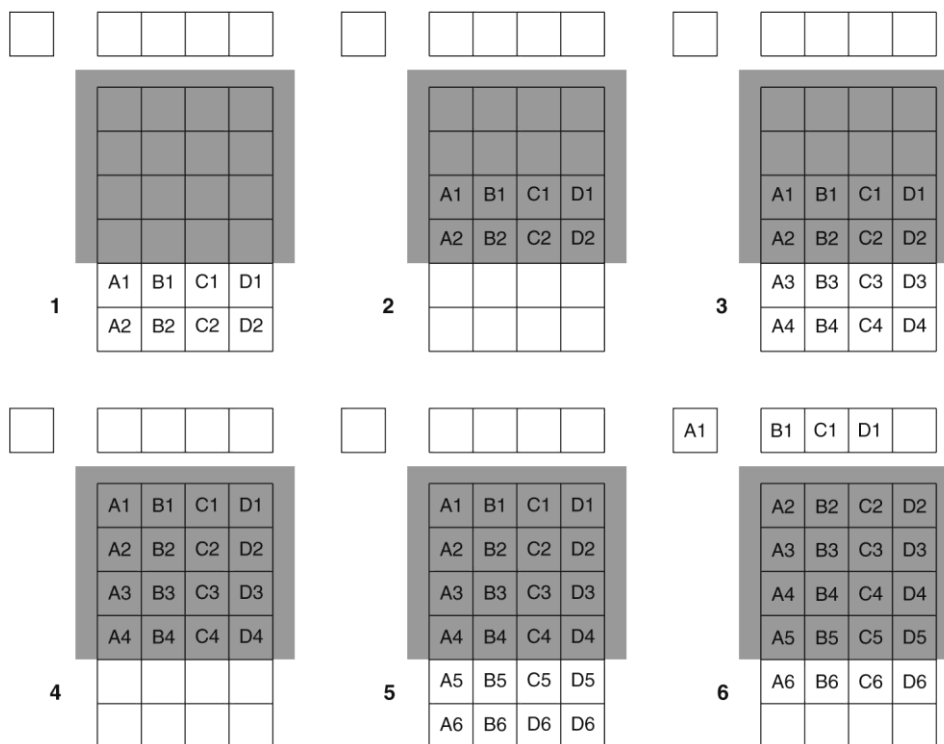


Figure 38. Kinetics Readout

### ***Kinetic Timing Modes and Shutter Control***

Kinetics mode operates with three timing modes: Free Run {No Response}, Single Trigger {Readout Per Trigger}, and Multiple Trigger {Shift Per Trigger}. Free run {No Response} mode is used for experiments that do not require any synchronization with the experiments. The other two modes (single trigger and multiple trigger) require that an external TTL pulse be applied to the camera via the **EXT SYNC** connector on the rear of the camera.

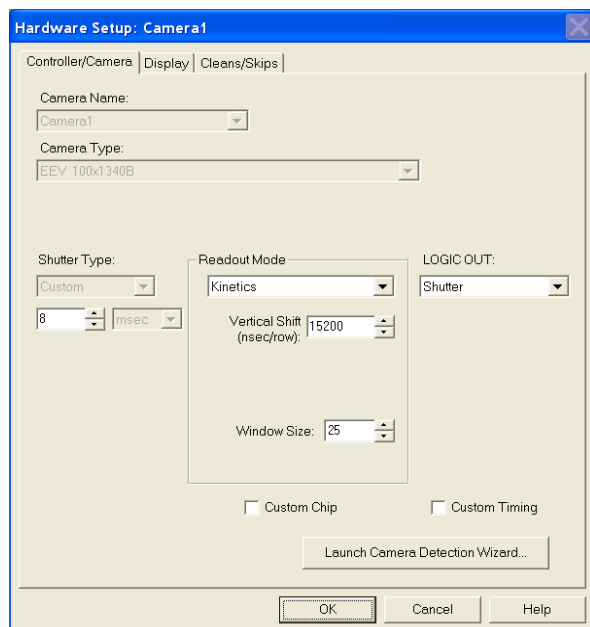


Figure 39. Hardware Setup dialog

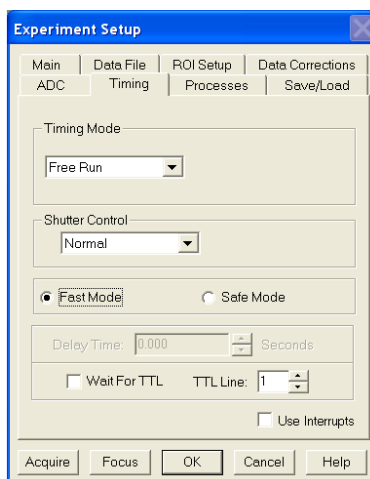


Figure 40. Experiment Setup dialog

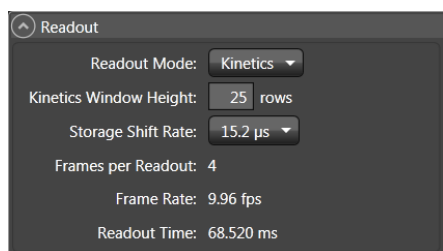


Figure 41. Sensor Readout expander:  
Kinetics Readout Mode

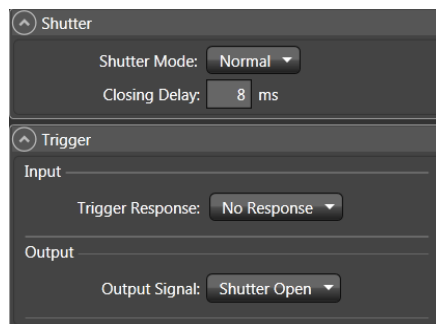


Figure 42. Shutter and Trigger expanders:  
No Response

### ***Free Run (Non-Triggered Mode)***

In the Free Run {No Response} kinetics mode, the PIXIS takes a series of images, each with the Exposure time set through the software (in WinX, the exposure time is set on the **Experiment Setup|Main** tab; in LightField on the **Common Acquisition Settings** expander). The time between image frames, which may be as short as a few microseconds, is limited by the time required to shift an image under the mask: this interimage time equals the Vertical Shift rate (specified in ns/row) multiplied by the Window Size (the number of rows allocated for an image frame). The exact number of frames depends on the selected Window Size and is equal to the number of pixels perpendicular to the shift register divided by the

Window Size. Integrate signals (SHUTTER {Shutter Open}) or Readout signals (NOT SCAN {Not Reading Out}) are provided at the **LOGIC OUT** connector for timing measurements.

**Example:** Referring to the readout shown in Figure 38, there are 6 pixels perpendicular to the shift register and the Window Size is 2 pixels high. The number of frames is 3. If the Vertical Shift rate for the CCD is 1600 ns/row, the Shift time will be 3200 ns per frame.

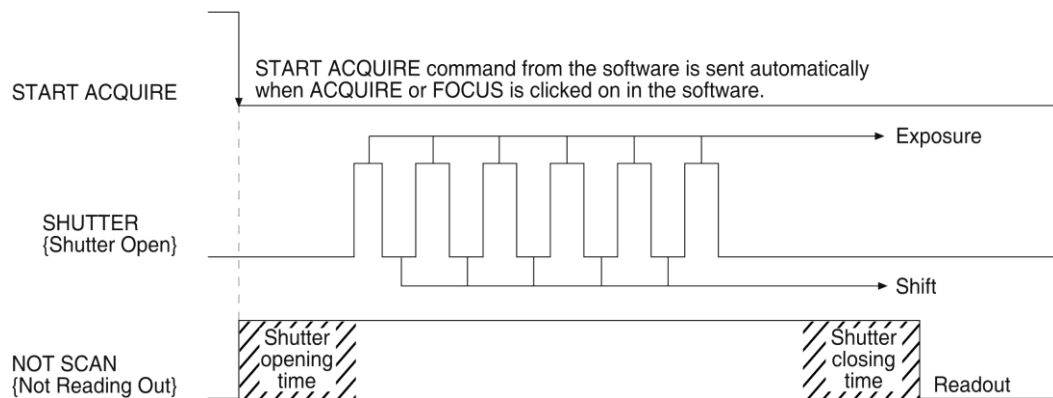


Figure 43. Free Run Timing Diagram

### Triggered Modes

In single trigger mode, the camera requires only one trigger to initiate an entire series of “exposure-shift” cycles as shown in the timing diagram below. When Acquire or Focus {Run} is clicked, the shutter is opened and the camera uses the exposure time as entered in the software. The trigger is applied at the **Ext Sync** connector on the rear of the PIXIS. After the series is complete the shutter closes and the CCD is read out at normal speeds. Once the readout is complete the camera is ready for the next series of exposures. This timing is shown in Figure 44, where a single External trigger pulse is used to collect a burst of 6 frames.

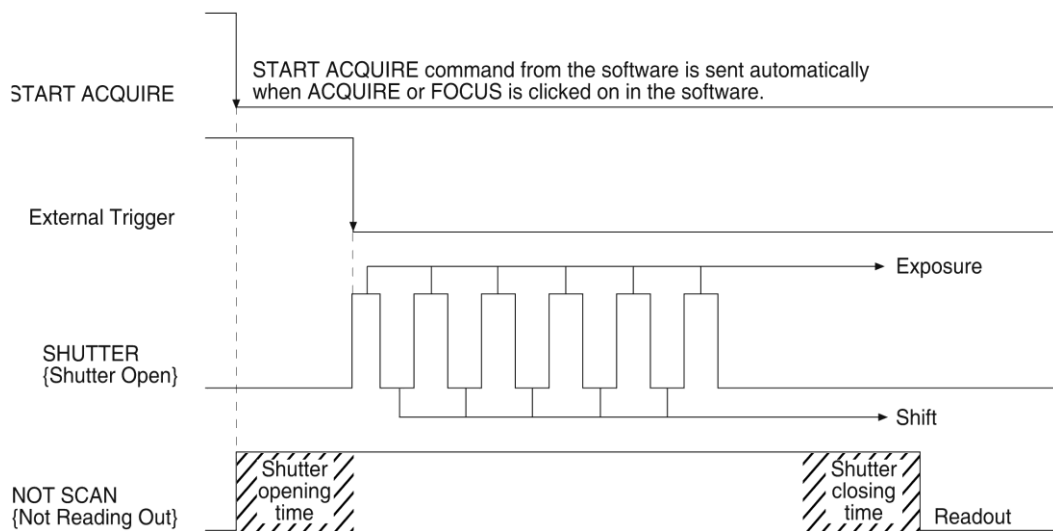


Figure 44. Single Trigger Timing Diagram

In multiple trigger mode, the shutter is opened when Acquire or Focus {Run} is clicked and each “exposure-shift” cycle in the acquisition is triggered independently by a pulse applied at the **EXT SYNC** connector. This mode is useful when each subframe needs to be synchronized with a pulsed external light source such as a laser. Once the series is complete, the shutter closes and readout begins. Since the shutter is open during the entire series of images, irregularly spaced external pulses will result in exposures of different lengths. Once the series has been read out, the camera is ready for the next series. This timing is shown in Figure 45, where a series of 6 frames is collected with 6 External Sync pulses.

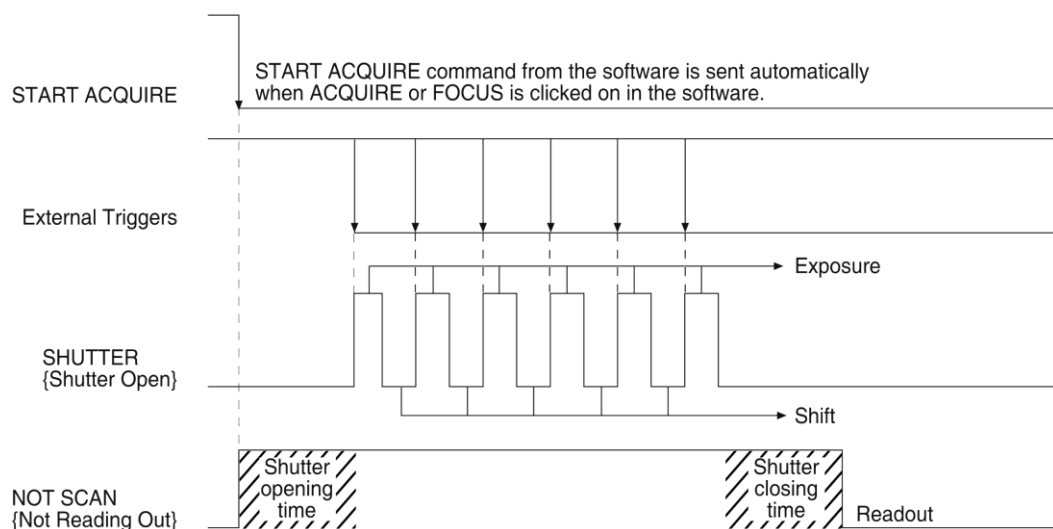


Figure 45. Multiple Trigger Timing Diagram

## Custom Modes

### ***Introduction***

Custom Chip and Custom Timing modes are available as an option for the WinX applications; {Custom Sensor} and Custom Timing are standard (sensor and readout mode-dependent) in LightField. These modes are intended to allow data acquisition at the fastest possible rates for your camera. Custom Chip {Custom Sensor} allows you to reduce the apparent size of the CCD array and Custom Timing allows you to select a faster vertical shift time.

### ***Custom Chip***

#### ***Introduction***

In addition to Binning and ROI (previously discussed in the manual), there is a third way to reduce Readout Time – Custom Chip {Custom Sensor}. This feature allows you to redefine the size of the CCD’s active area via software. Unlike setting a smaller region of interest (ROI), which also involves reading out fewer pixels, this mode does not incur overhead from discarding or skipping the rest of the rows. And, unlike both Binning and ROI, Custom Chip {Custom Sensor} also relies on some form of array masking to ensure that no light falls outside the currently set active area.

**Note:** Custom Chip is a WinX option. Custom Sensor is standard with LightField: availability is sensor-dependent.

### Software Settings

Princeton Instruments does not encourage users to change these parameter settings. For most applications, the default settings will give the best results. We **strongly advise** contacting the factory for guidance before customizing the chip definition.

In WinX, if Custom Chip has been installed, selecting **Show Custom Chip** check box on the **Controller/Camera** tab adds the **Custom Chip** tab to the **Hardware Setup** dialog. The Custom Chip parameters are shown in Figure 46. The default values conform to the physical layout of the CCD array and are optimum for most measurements.

In LightField, the **Custom Sensor** pane (Figure 47) is accessed by opening the **Sensor** expander and clicking on the **Custom Sensor** button.

By changing the values in the Active fields, you can increase image acquisition speed by reducing the size of the active area in the definition. The result will be faster but lower resolution data acquisition. Operating in this mode would ordinarily require that the chip be masked so that only the reduced active area is exposed. This will prevent unwanted charge from spilling into the active area or being transferred to the shift register.

By default, if there are no Pre-Dummy rows, the serial register will be cleared before rows are shifted. If the **Skip Serial Register Clean** box is selected in WinX when there are no Pre-Dummy rows, the register cleanout will be skipped and the chip readout will be faster.

**Note:** In LightField, the **Clean Serial Register** function only appears in the **Sensor Cleaning** pane when the **Inactive Area Top Margin** is 0 rows. Deselect the check box to deactivate the serial register cleaning.

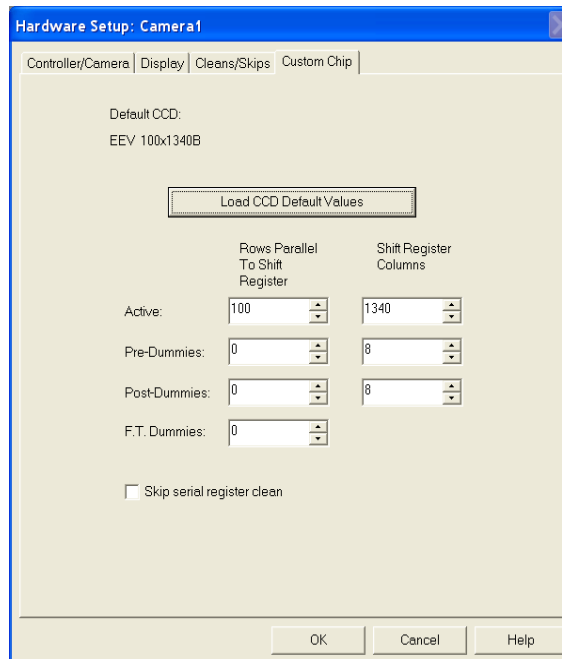


Figure 46. WinX: Custom Chip tab

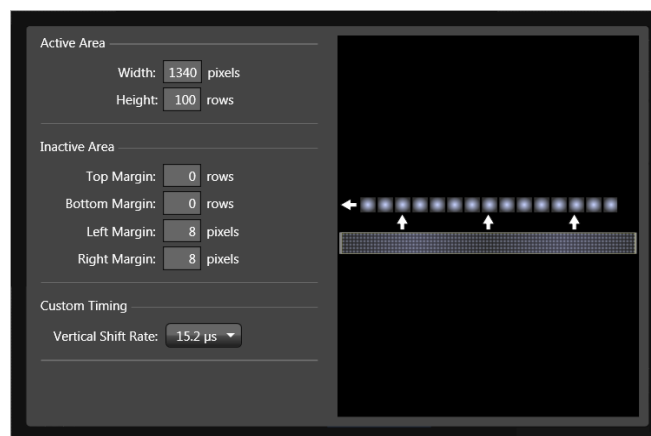


Figure 47. LightField: Custom Sensor pane

## Custom Timing

### Notes:

1. This mode is standard with LightField for full frame CCD cameras.
2. This option is fully supported by WinX Version 2.5.18.1 (and higher).
3. This option is not supported by WinX for 5 MHz systems..

In LightField, Custom Timing is accessed via the **Custom Sensor** button on the **Sensor** expander. In the **Custom Timing** panel, you can select from among the listed vertical shift rate choices (see Figure 48). Vertical shift rate is the time required to shift one row into the serial register. The smaller the value, the faster charge will be shifted up one row at a time toward the serial register. In WinX, if the Custom Timing option is present and selected, the equivalent function is located on the **Custom Timing** tab on the **Hardware Setup** dialog (see Figure 49).

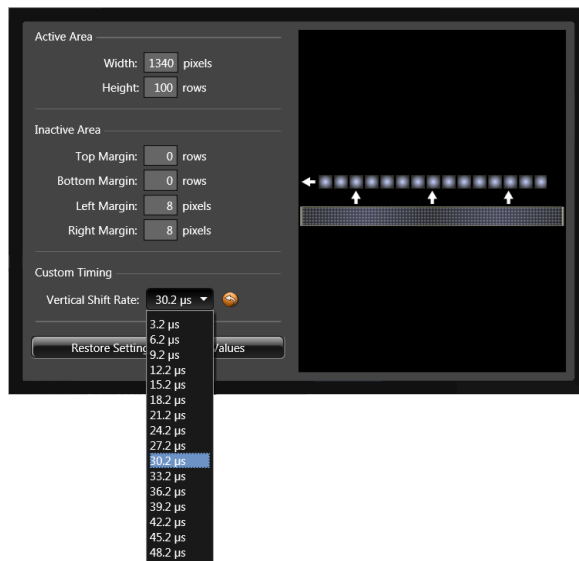


Figure 48. LightField: Custom Timing

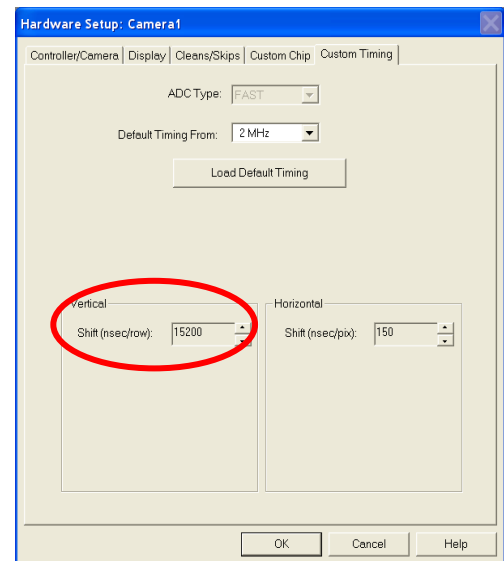


Figure 49. WinX: Vertical Shift



# Chapter 7

## Troubleshooting

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**WARNING!** Do not attach or remove any cables while the camera system is powered on.

### Introduction

The following issues have corresponding troubleshooting sections in this chapter.

Acquisition Started but Viewer Contents Do Not Update	Page 82
Baseline Signal Suddenly Changes	Page 82
Camera Stops Working	Page 82
Camera1 (or similar name) in Camera Name field	Page 83
Controller Is Not Responding	Page 84
CoolCUBE <sub>II</sub> : Low Coolant (Air in the Hoses)	Page 84
Cooling Troubleshooting	Page 85
Data Loss or Serial Violation	Page 86
Data Overrun Due to Hardware Conflict message	Page 86
Data Overrun Has Occurred Message	Page 87
Device Is Not Found	Page 87
Device is Occupied	Page 88
Error Creating Controller message	Page 88
Overexposed or Smeared Images	Page 88
Program Error message	Page 89
Serial violations have occurred. Check interface cable.	Page 90
Shutter Failure	Page 90

## Acquisition Started but Viewer Contents Do Not Update

In LightField, live data is normally displayed in the Experiment workspace viewer as it is being acquired (Preview or Acquire mode). If the viewer is not being updated and acquisition is occurring, check to see if there is a filename in the top row of the viewer: in the figure below, the filename 2010 May 11 13\_13\_49.raw is displayed. If there is a filename, click on the camera icon. The file data will be cleared from the viewer and the live data will then be displayed.

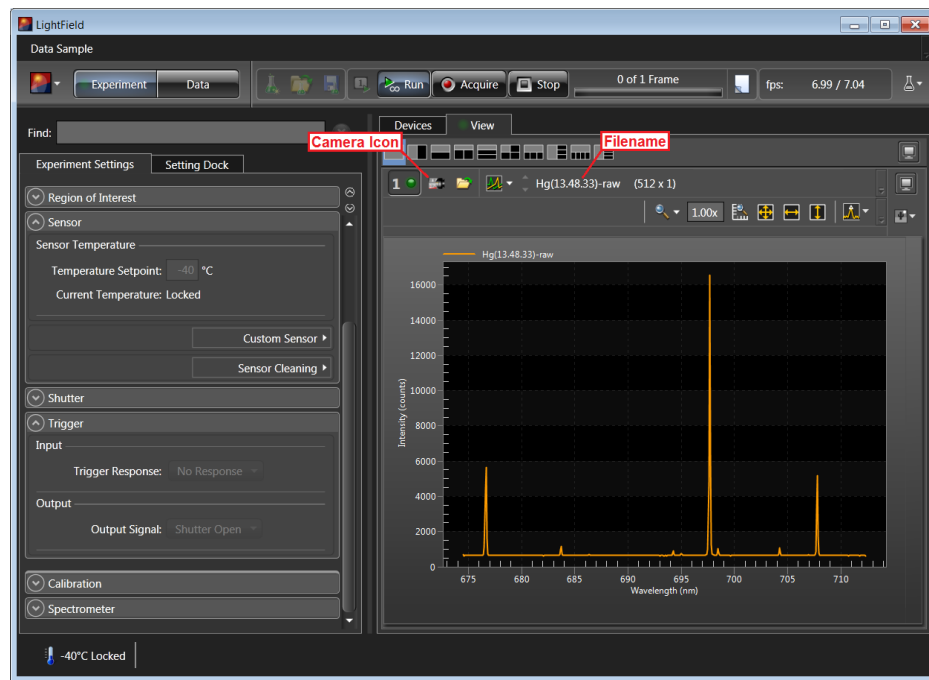


Figure 50. Acquisition Display

## Baseline Signal Suddenly Changes

A change in the baseline signal is normal if the temperature, gain, or speed setting has been changed. If this occurs when none of these settings have been changed, there may be excessive humidity in the camera vacuum enclosure. Turn off the camera and contact Princeton Instruments Customer Support. See page 126 for contact information.

## Camera Stops Working

Problems with the host computer system or software may have side effects that appear to be hardware problems. If you are sure the problem is in the camera system hardware, begin with these simple checks:

- Turn off all AC power.
- Verify that all cables are securely fastened.
- Turn the system on.
- If the camera has an internal shutter and you hear 2 clicks separated by 1 second (shutter opening then closing), the shutter is working. Call Princeton Instruments Customer Support for further instructions.

If the system still does not respond, contact Princeton Instruments Customer Support.

## Camera1 (or similar name) in Camera Name field

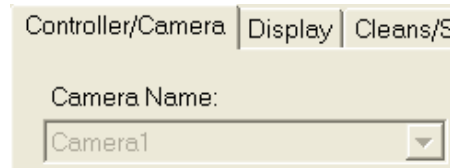
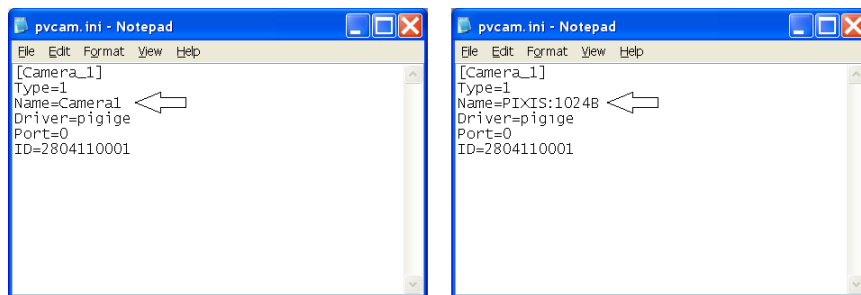


Figure 51. Camera1 in Camera Name Field

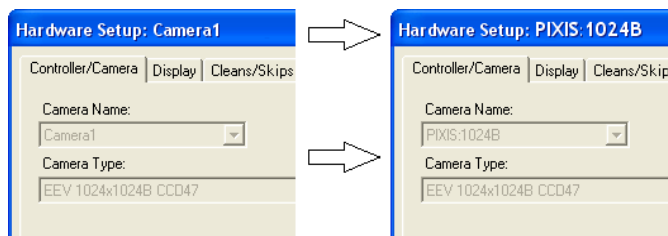
When the Camera Detection Wizard installs a new camera, the camera is automatically named “Camera#” (where # = 1, 2, or 3..., depending on the number of cameras detected). This name will appear in the **Hardware Setup** title bar and as the active camera on the **Hardware Setup|Controller/Camera** tab. If you would prefer a more specific name, you can edit PVCAM.INI (located in the Windows directory) and rename the camera. The new name will then be used by the system until the Camera Detection Wizard is run again.

### To change the default Camera Name:

1. Close the application program if it is running.
2. Using Notepad.exe, open PVCAM.INI from the **Windows** directory.
3. Edit the **Name**.



4. Save the edited file.
5. The next time you start the WinX application, the new name will be displayed on the **Hardware Setup** dialog.



6. If you later re-run the Camera Detection Wizard, the name will be changed back to the default name (i.e., Camera1).

## Controller Is Not Responding

If this message pops up when you click on **OK** after selecting the "Interface Type" during **Hardware Setup** (under the WinX **Setup** menu), the system has not been able to communicate with the camera. Check to see if camera has been turned ON and if the USB 2.0 interface card, its driver, and the USB cable have been installed.

- If the camera is ON, the problem may be with the USB 2 card, its driver, or the cable connections.
- If the interface card is not installed, close the WinX application and turn the camera OFF. Follow the interface card installation instructions in provided with your interface card, and cable the card to the USB 2 port on the rear of the camera. Then do a "Custom" installation of the WinX application with the appropriate interface component selected. Be sure to deselect the interface component that does not apply to your system.
- If the interface card is installed in the computer and is cabled to the USB 2 port on the rear of the camera, close the application and turn the camera OFF. Check the cable connections.
- If the interface card was installed after the application program was installed, close the application program and do a "Custom" installation of the WinX application with the appropriate interface component selected. Be sure to deselect the interface component that does not apply to your system.

## CoolCUBE<sub>II</sub>: Low Coolant (Air in the Hoses)

### WARNING!

If more than two inches (50.8 mm) of the coolant line is filled with air, the pump will stop working and may be damaged. If flow stops while the pump is on, turn off the CoolCUBE<sub>II</sub> and add coolant.

1. Unscrew the reservoir cap (on top of the CoolCUBE<sub>II</sub>) and make sure that the coolant reservoir contains coolant. If additional coolant is required, fill with a 50:50 mixture of water and ethylene glycol.
2. Screw the reservoir cap back in.
3. Make sure the power switch is turned off before plugging the circulator in.
4. Plug the circulator into a 100-240 VAC, 47-63 Hz power source.
5. Turn the circulator on. Make sure there are no leaks or air bubbles in the hoses.

**Note:** Small air bubbles (about the size of bubbles in soda) are common in the CoolCUBE<sub>II</sub> especially at start up and do not prevent proper operation.

- If there are no problems, continue to Step 6.
  - If there are leaks or air bubbles, turn the circulator off and correct the problem(s) by securing the hoses or adding more coolant to the reservoir. Turn the circulator back on. Recheck and if there are no problems, continue to Step 6.
6. Turn the camera on.
  7. Start the application software.

## Cooling Troubleshooting

### ***Temperature Lock Cannot be Achieved or Maintained.***

Possible causes for not being able to achieve or maintain lock could include:

- Ambient temperature greater than +23°C. This condition affects TE-cooled cameras. If ambient is greater than +23°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera and/or circulator is obstructed. The camera needs to have approximately two (2) inches (50 mm) clearance around the vented covers. If there is an enclosure involved, the enclosure needs to have unrestricted flow to an open environment. The camera vents its heat out the vents near the nose. The air intake is near the rear of the camera.
- A hose is kinked. Unkink the hose.
- Coolant level is low. Add coolant. See “*CoolCUBE<sub>II</sub>: Low Coolant (Air in Hoses)*” on page 84.
- There may be air in the hoses. Add coolant. See “*CoolCUBE<sub>II</sub>: Low Coolant (Air in Hoses)*” on page 84.
- Circulator pump is not working. If you do not hear the pump running when the CoolCUBE<sub>II</sub> is powered on, turn off the circulator and contact Customer Support.
- The circulator is higher than the camera. Reposition the circulator so that it is 6 inches (150 mm) or more below the camera. The vertical distance should not exceed 10 feet (3 m). Typically, the camera is at table height and the circulator is on the floor.
- The camera vacuum has deteriorated and needs to be refreshed. Contact Customer Support.
- The target array temperature is not appropriate for your particular camera and CCD array.
- For a TE-cooled camera, the camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. TE-cooled cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

### ***Camera loses Temperature Lock***

The internal temperature of the camera is too high. This might occur if the operating environment is particularly warm or if you are trying to operate at a temperature colder than the specified limit. If this happens, an internal thermal overload switch will disable the cooler circuits to protect them. Typically, camera operation is restored in about ten minutes. Although the thermal overload switch will protect the camera, users are advised to power down and correct the operating conditions that caused the thermal overload to occur.

### **Gradual Deterioration of Cooling Capability**

While unlikely with the PIXIS camera (guaranteed permanent vacuum for the life of the camera), if you see a gradual deterioration of the cooling capability, there may be a gradual deterioration of the camera's vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. In the kind of applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's lowest temperature performance because lower temperatures result in lower thermal noise and better the signal-to-noise ratio. Contact the factory to make arrangements for returning the camera to the support facility.

## **Data Loss or Serial Violation**

You may experience either or both of these conditions if the host computer has been set up with Power Saving features enabled. This is particularly true for power saving with regard to the hard drive. Make sure that Power Saving features are disabled while you are running the WinX application.

## **Data Overrun Due to Hardware Conflict message**

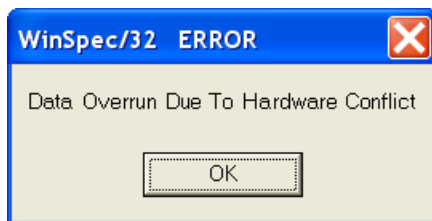


Figure 52. Data Overrun Due to Hardware Conflict dialog

If this dialog appears when you try to acquire a test image, acquire data, or run in focus mode, check the CCD array size and then check the DMA buffer size. A large array (for example, a 2048x2048 array), requires a larger DMA buffer larger setting than that for a smaller array (for example, a 512x512 array).

### **To change the DMA buffer setting:**

1. Note the array size (on the **Setup|Hardware|Controller/CCD** tab or the **Acquisition|Experiment Setup|Main** tab Full Chip dimensions).
2. Open **Setup|Environment|Environment** dialog.
3. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close the WinX application.
4. Reboot your computer.
5. Restart the WinX application and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

## Data Overrun Has Occurred message

Because of memory constraints and the way that USB transfers data, a "Data overrun has occurred" message may be displayed during data acquisition. If this message is displayed, take one or more of the following actions:

1. Minimize the number of programs running in the background while you are acquiring data with the WinX application.
2. Run data acquisition in Safe Mode.
3. Add memory.
4. Use binning.
5. Increase the exposure time.
6. Defragment the hard disk.
7. Update the USB2 driver.

If the problem persists, your application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user. However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If your experiment requirements include long data acquisition times and/or large data sets, your application may not be suitable for the USB 2.0 interface. If this is not the case and data overruns continue to occur, contact Customer Support (see page 126 for contact information).

## Device Is Not Found

When LightField is started, it looks for devices (cameras, spectrographs, and filters) that are powered on and connected via a communications interface to the host computer. If it cannot find a device that was used in the last experiment, it will continue to look for it.



Figure 53. Devices Missing dialog

- Make sure the device is connected and powered on. If the device is connected but turned off, switch it on. LightField should now find the device. If it does not, cancel the load and restart LightField.

- Cancel the load. Cancelling a load means that the last used experiment will not be loaded automatically when LightField opens. However, you can load the experiment after all the devices are available, you can start a new experiment design, or you can load a different experiment that matches the devices you are using.

## Device is Occupied

Multiple instances of LightField can be running at the same time. However, a device currently being used by one instance of LightField will be shown in the **Available Devices** area as “Occupied” for all other instances of LightField. To make a device available to the current instance of LightField, either remove it from the **Experiment Devices** area in the other instance or close the instance that is using the device.

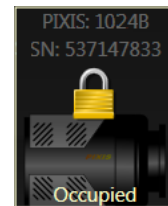


Figure 54. Occupied Device icon

## Error Creating Controller message

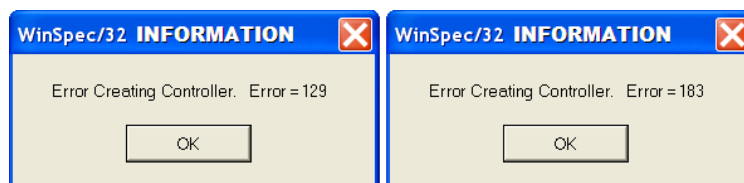


Figure 55. Error Creating Controller dialog

This message may appear if the PVCAM.INI file has become corrupted or if the camera was not turned on before you started the WinX application and began running the Camera Detection wizard. If one of these dialogs pops up:

1. See "**Controller Is Not Responding**," page 84.
2. Run the Camera Detection Wizard.

## Overexposed or Smeared Images

If the camera has an internal shutter, check to see that the shutter is opening and closing correctly. Possible shutter problems include complete failure, in which the shutter no longer operates at all: the shutter may stick or open (causing overexposed or smeared images) or stick closed (resulting in no images). It may even happen that one leaf of the shutter will break and no longer actuate. High repetition rates and short exposure times will rapidly increase the number of shutter cycles and hasten the time when the shutter will have to be replaced.

Shutter replacement is usually done at the factory. If you find that the shutter on your camera is malfunctioning, contact the factory to arrange for a shutter-replacement repair. **Shutters are not covered by the warranty.**



## Program Error message

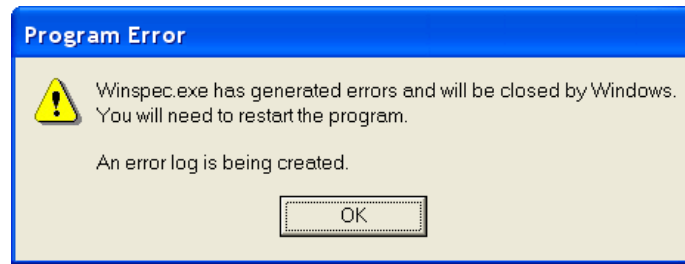


Figure 56. Program Error dialog

This dialog may appear if you have tried to acquire a test image, acquire data, or run in focusing mode and the DMA buffer size is too small.

### To correct the problem:

1. Click on **OK**.
2. Reboot the WinX application.
3. Note the array size (on the **Setup|Hardware|Controller/CCD** tab or the **Acquisition|Experiment Setup|Main** tab Full Chip dimensions). If your camera contains a large array (such as a 2048x2048 array), and the DMA buffer size is too small, there will not be enough space in memory for the data set.
4. Open **Setup|Environment|Environment** dialog.
5. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close the WinX application.
6. Reboot your computer.
7. Restart the WinX application and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

## Serial violations have occurred. Check interface cable.



Figure 57. Serial Violations Have Occurred dialog

This error message dialog will appear if you try to acquire an image or focus the camera and either (or both) of the following conditions exists:

- The camera system is not turned ON.
- There is no communication between the camera and the host computer.

### To correct the problem:

1. Turn **OFF** the camera system (if it is not already OFF).
2. Make sure the computer interface cable is secured at both ends.
3. After making sure that the cable is connected, turn the camera system power **ON**.
4. Click **OK** on the error message dialog and retry acquiring an image or running in focus mode.

**Note:** This error message will also be displayed if you turn the camera system OFF or a cable comes loose while the WinX application software is running in Focus mode.

## Shutter Failure

See "*Overexposed or Smeared Images*", page 88.

# Appendix A

## Basic Specifications

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*Note:* This appendix provides some of the basic specifications of a PIXIS system. If the information you are looking for is not here, it may be available in Appendix B, "*Outline Drawings*" or on the appropriate data sheet. Data sheets can be downloaded from the Princeton Instruments website ([www.princetoninstruments.com](http://www.princetoninstruments.com)).

### Window

SI-UV fused-silica quartz (.125"/3.17 mm thick)

### CCD Arrays

Princeton Instruments offers a wide-variety of CCDs for scientific imaging and spectroscopy. Contact Princeton Instruments or visit [www.princetoninstruments.com](http://www.princetoninstruments.com) for an up-to-date list of arrays supported by the PIXIS.

### Mounts

C-mount: Standard threaded video mount. Optional adjustable C- to Spectroscopy-mount kinetics adapter

F-mount: Standard Nikon® bayonet mount.

Spectroscopy mount: 3.60" (91.44 mm) or 3.88" (98.55 mm) bolt circle. Optional Spectroscopy-to-F mount adapter

### Focal Distance (Optical)

The distance to the focal plane from the front of the mechanical assembly depends on the specific configuration as follows. Note that neither set of reference points includes an adapter.

Application Type	Adapter Type	Reference Points	Distance
Imaging	C-Mount	Face of Camera to Focal Plane	0.690" /17.53 mm (optical)
	F-Mount	Face of Camera to Focal Plane	1.83"/46.48 mm (optical)
Spectroscopy	Spec-Mount (3.60" bolt circle, flange)	Mounting Flange to Focal Plane	0.600"/15.24 mm (optical)
	Spec-Mount (3.60"/3.88" bolt circle)	Mounting Flange to Focal Plane	0.886"/22.50 mm (optical)

Table 4. Focal Plane Distances

## Shutter

Typically, PIXIS cameras for imaging applications are shipped with an internal shutter.

- **PIXIS:512/1024:** Internal, windowless, 1 in (25 mm) aperture, 8 ms open time, 8 ms close time
- **PIXIS:2048:** Internal, windowless, 1.8 in (45 mm) aperture, ~ 20 ms open time, ~48 ms close time

Typically, PIXIS cameras for spectroscopy applications do not have an installed internal shutter. An optional Princeton Instruments-supplied 25 or 45 mm external shutter can be ordered if the camera has no internal shutter.

## Camera

**Cooling:** Thermoelectric; air or circulating coolant

**Coolant Ports:** The inlet/outlet ports on the side of the camera allow you to connect the camera to a CoolCUBE<sub>II</sub> with PIXIS-compatible hoses (PN 7567-0002). Use only the hoses and circulator shipped with your system. Attaching any other hoses or circulator voids the warranty

**Gain:** Software-selectable (high, medium, low)

**Dimensions:** See Appendix B.

### Connectors:

**EXT SYNC (MCX):** 0 to +3.3 V logic level input to allow data acquisition to be synchronized with external events. Trigger edge can be positive- or negative-going as set in software. Synchronization and Timing Modes are discussed in Chapter 6. MCX-to-BNC adapter cable supplied with system.

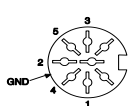
**LOGIC OUT (MCX):** 0 to +3.3 V logic level output for monitoring camera status. *Logic output is software-selectable as NOT SCAN, SHUTTER, NOT READY, LOGIC 0, or LOGIC 1.* Logic Out Control is discussed in Chapter 6. MCX-to-BNC adapter cable supplied with system.

- **NOT SCAN {Not Reading Out}:** Logic low when CCD is being read; otherwise high.
- **SHUTTER {Shutter Open}:** The output precisely brackets shutter-open time (exclusive of shutter compensation) and can be used to control an external shutter or to inhibit a pulser or timing generator.
- **NOT READY {Busy}:** The output changes state on completion of the array cleaning cycles that precede the first exposure. Initially high, it goes low to mark the beginning of the first exposure. In free run operation, it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken, then returns high.
- **LOGIC 0 {Always Low} and LOGIC 1 {Always High}:** Logic low and logic high, respectively.

**Shutter (LEMO):** Optional. Used for connecting to a Princeton Instruments-supplied external shutter. Cable not supplied.

**USB 2.0 (USB B Female):** Data link to computer via USB cable inserted at this connector. Cable length of 5 meters is standard. Other lengths may be available. Contact Customer Support for more information. USB A/B cable supplied with system.

**Power (DIN):** 12 VDC (6.6A max) input from power supply.



Pin 3, 5: 12 VDC
Pin 1, 2, 4: Return
Shell: Ground

**Fan:** (Air-cooled systems only) 24 CFM fan capacity at full power.

**Coolant Ports:** (Liquid-cooled systems only) Two interchangeable 1/4" CPC valved quick disconnect fittings for connection to the CoolCUBE<sub>II</sub> circulator hoses.

**Deepest Operating Temperature:**

CCD Size	Typical
512x512	-70°C
1024x1024	-70°C
2048x2048	-65°C
1340x100	-80°C
1340x400	-75°C

Table 5. Typical Deepest Operating Temperature

**Temperature Stability:**  $\pm 0.05^\circ\text{C}$ ; closed-loop stabilized-temperature control

**Power Input: Small Format PIXIS:** 100-240 V<sub>AC</sub>; 47 to 63 Hz, 1.9A. DC power to camera is provided by the self-switching power supply.

**Large Format PIXIS:** 100-240 V<sub>AC</sub>; 50/60 Hz, 2A. DC power to camera is provided by the self-switching power supply.

**Tripod Mount:** 1/4-20 x .25" mounting hole at bottom of camera. M6 threaded adapter supplied with system.

**A/D Converters:** Dual digitizers with 100 kHz/2 MHz readout rates. Software-selectable. Low-speed operation gives better noise performance; high-speed operation allows faster data acquisition.

## CoolCUBE<sub>II</sub> Circulator with PIXIS-compatible Hoses (PN 7567-0002)

### Closed loop system

**Hoses:** CoolCUBE<sub>II</sub> and **PIXIS-Compatible** 3/8" ID, with no-drip quick disconnects at the circulator ends and 1/4" CPC quick disconnects at the camera ends.

**Coolant:** 50:50 ethylene glycol and water at 23°C (DI water recommended).

**Dimensions:** Refer to *Appendix B, "Outline Drawings"*, page 106.

**Minimum Flow Rate:** 2.5 liters per minute.

**Maximum Pressure:** 22 PSI.

**Power Input:** 100 V/240 V, 3 A.

**Operating Environment:** +5°C to 30°C, non-condensing.

**Circulator Weight (Filled):** 6.0 lbs (2.7 kg).

**Hose Weight (Filled):** 3.0 lbs (1.4 kg) per hose.

## Options

A partial listing of options includes: internal 25 mm shutter, internal 45 mm shutter, C-to-F-mount adapter, adjustable C- to Spectroscopy-mount kinetics adapter, and a fiber optic extender kit. Contact the factory for more information regarding options available for your system.

# Appendix B

## Outline Drawings

**NOTE:** Dimensions are in inches [mm].

### PIXIS Camera: C-mount (Air-Cooled)

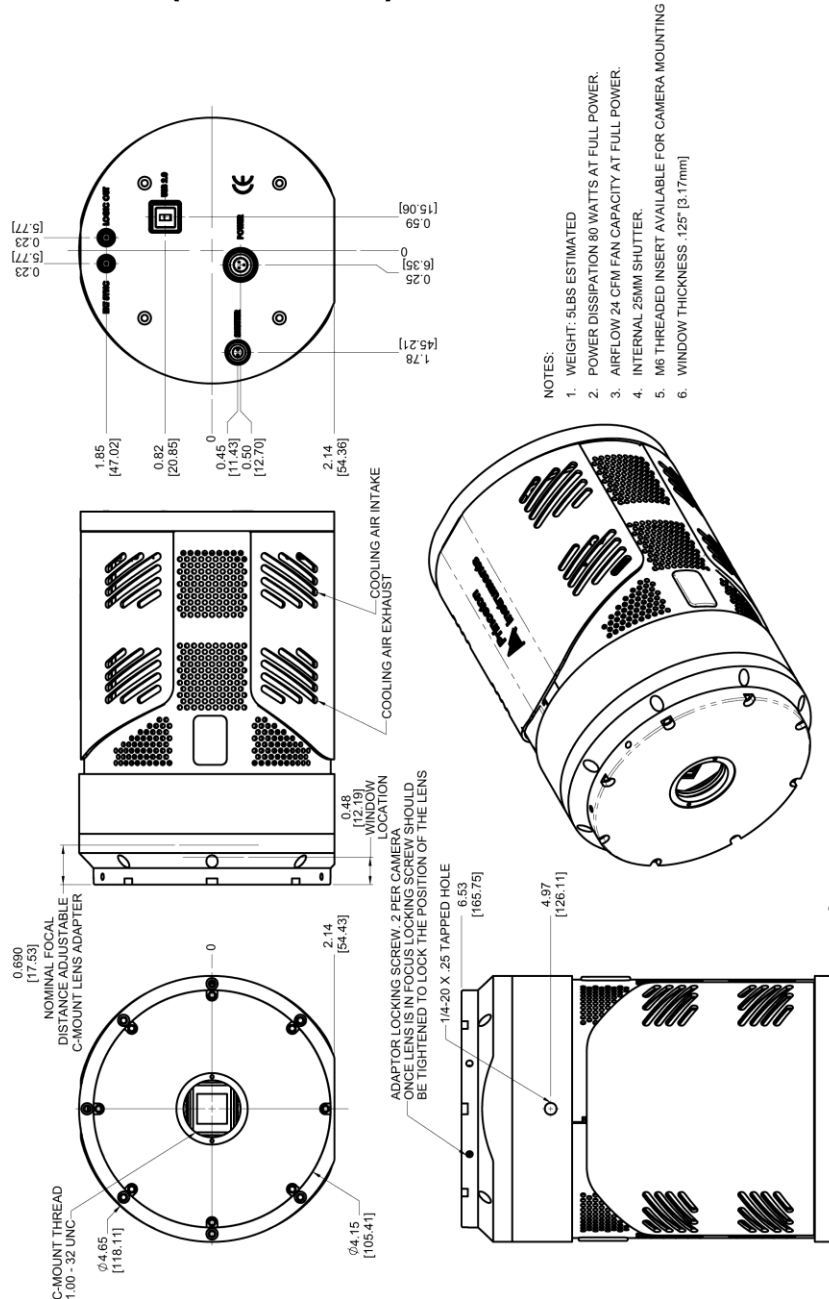


Figure 58. Adjustable C-Mount: Internal Shutter (Air-cooled)

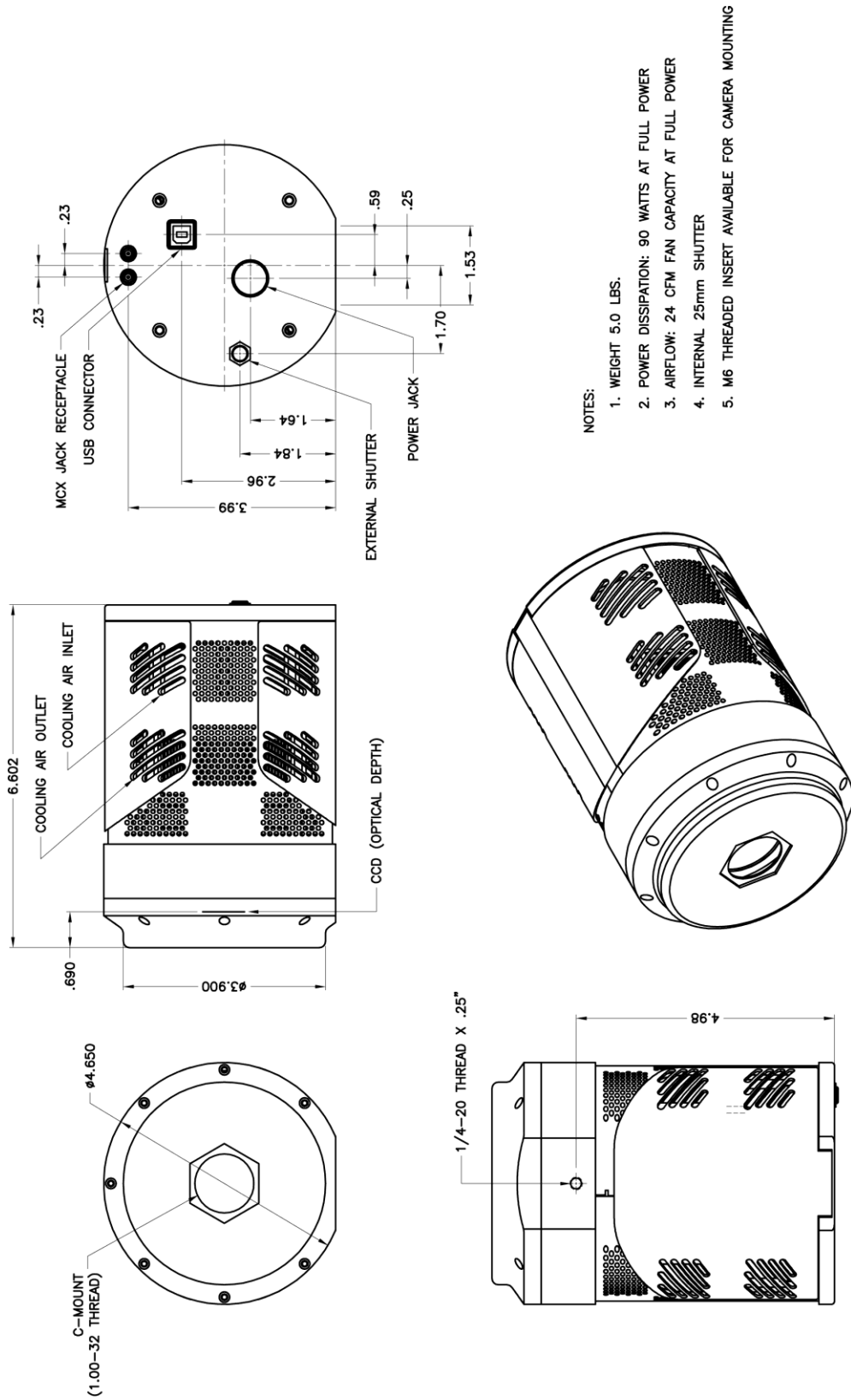


Figure 59. Fixed C-Mount: Internal Shutter (Air-cooled)



# PIXIS Camera: C-mount (Liquid-Cooled)

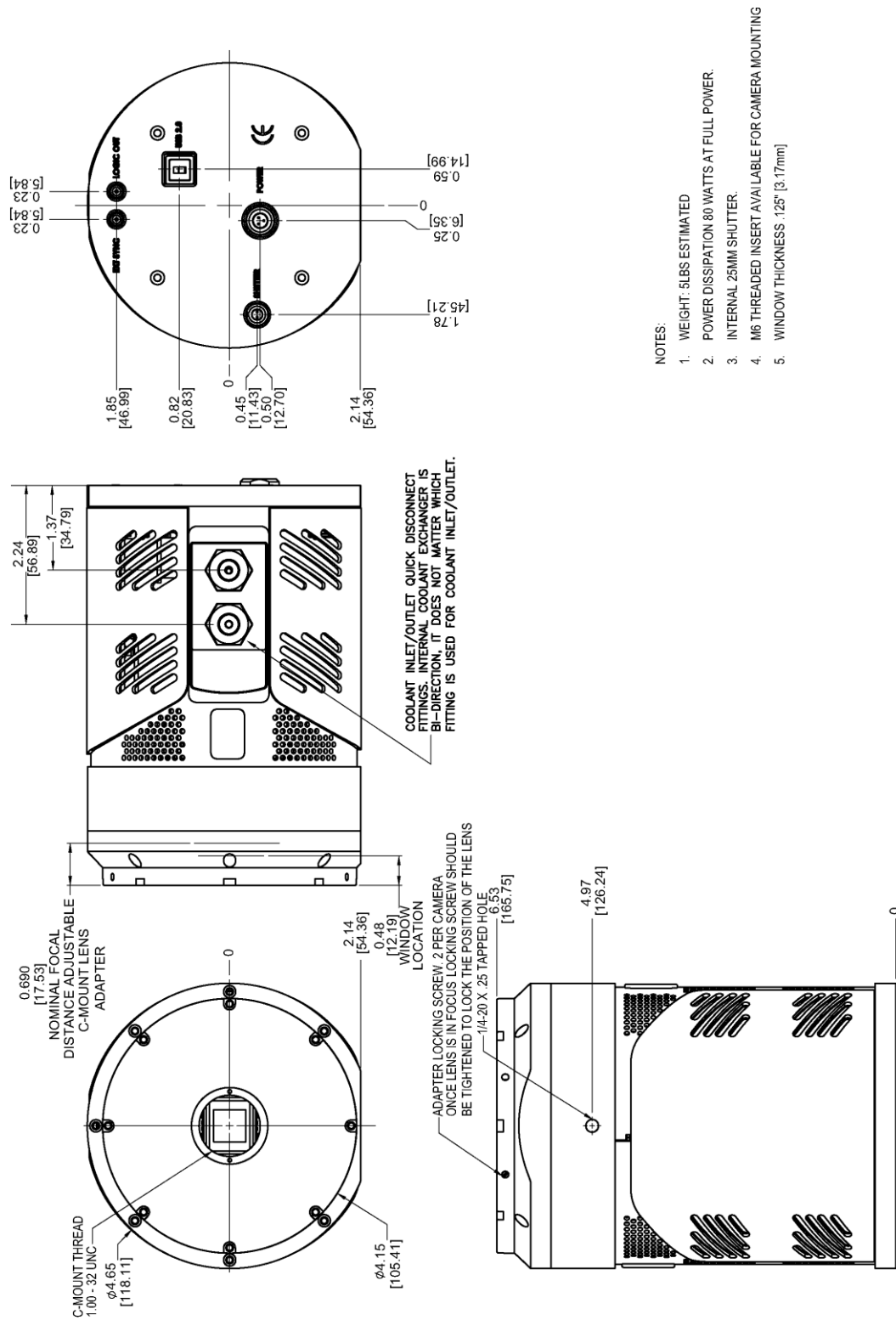


Figure 60. Adjustable C-Mount: Internal Shutter (Liquid-cooled)

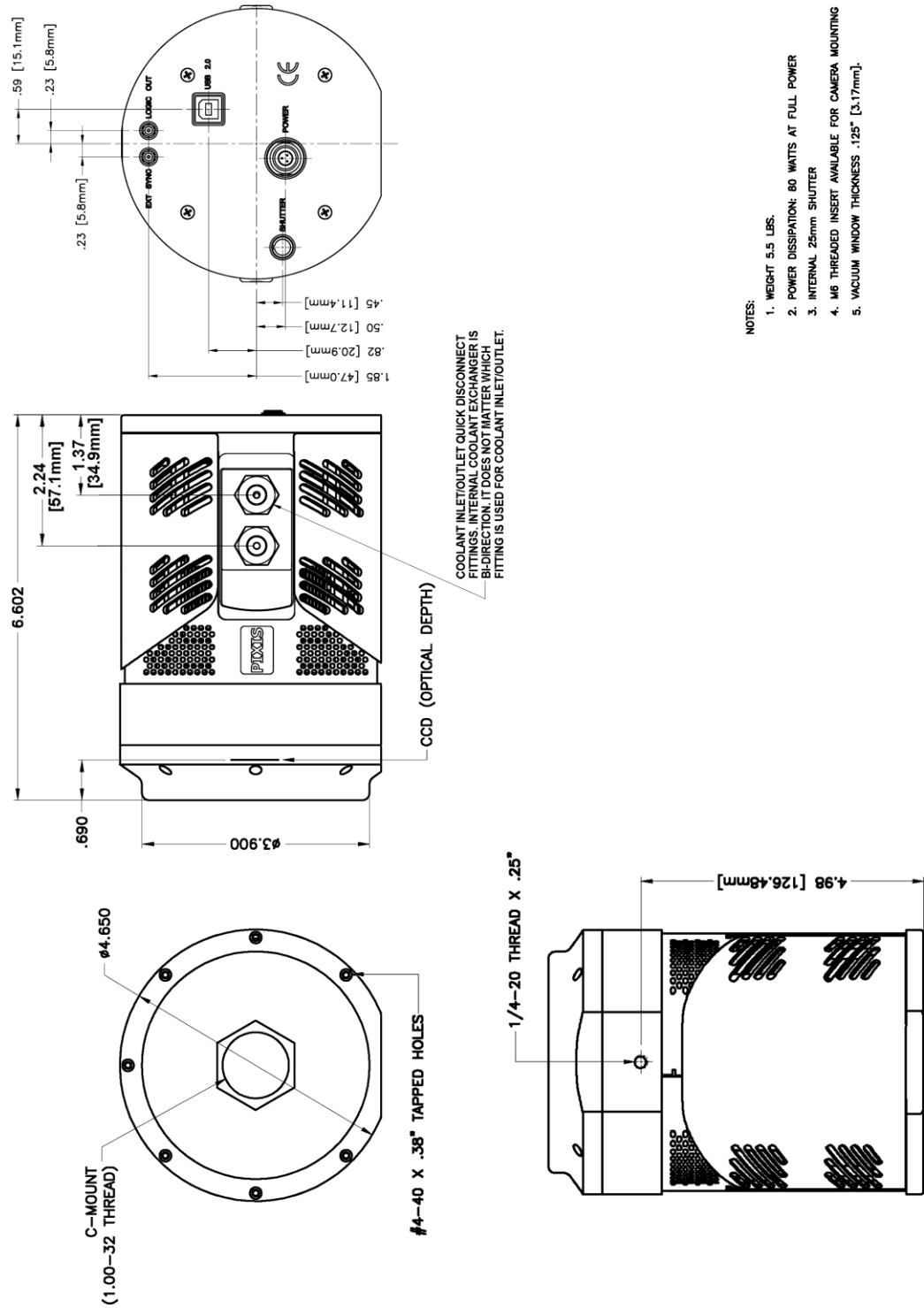


Figure 61. Fixed C-Mount: Internal Shutter (Liquid-cooled)

# PIXIS Camera: F-mount (Air-Cooled)

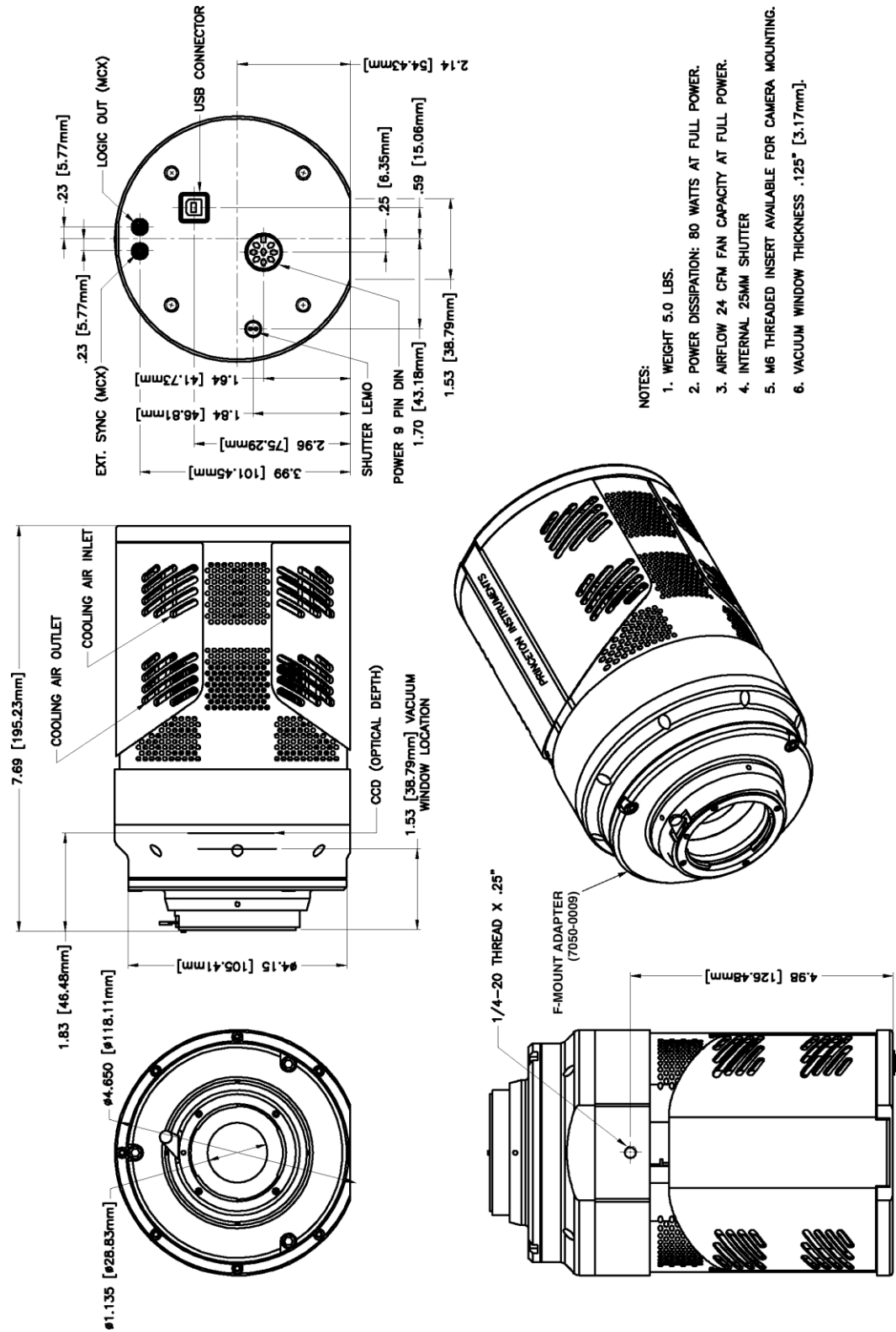
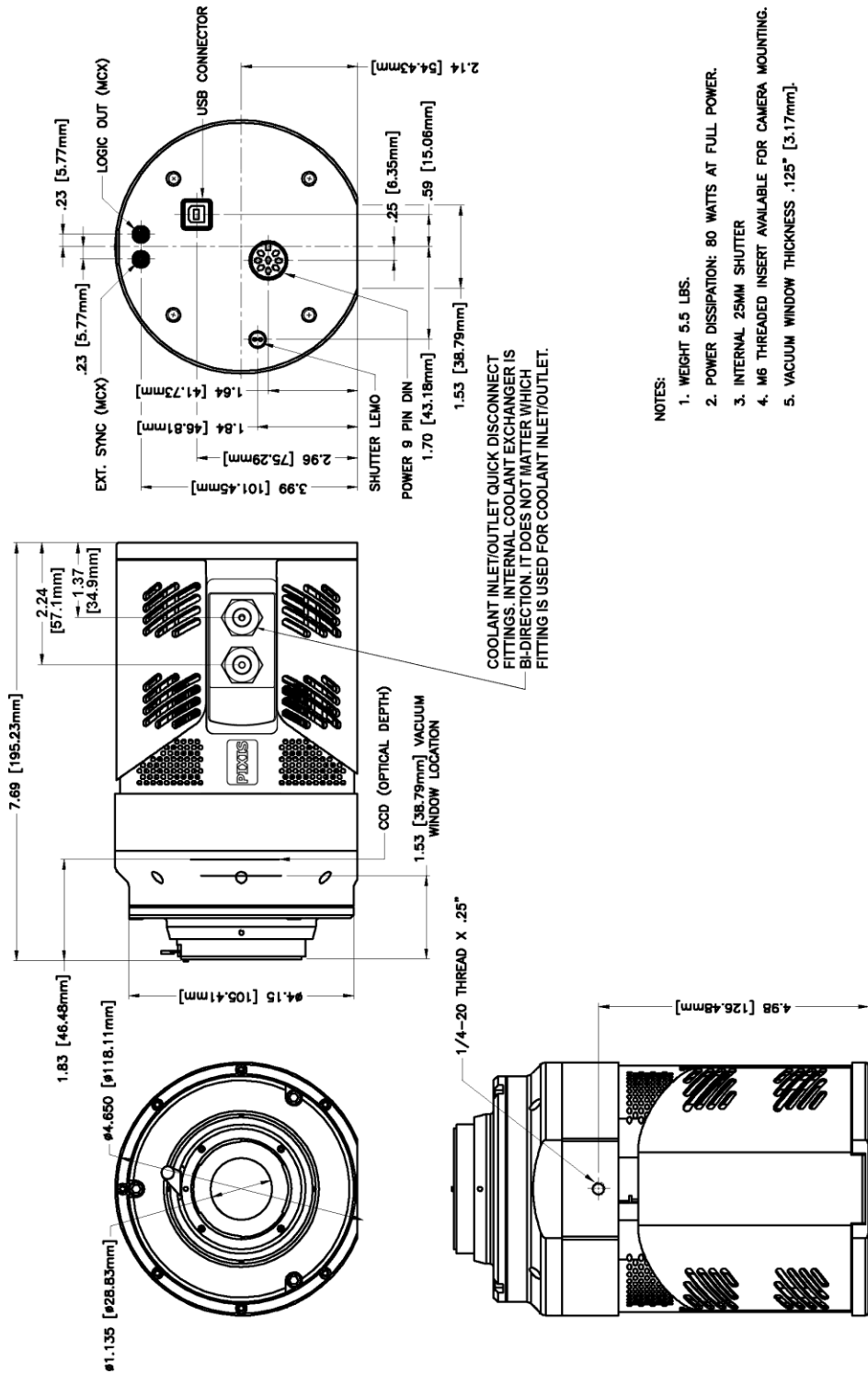


Figure 62. F-Mount: Internal Shutter (Air-cooled)

# PIXIS Camera: F-mount (Liquid-Cooled)



- NOTES:
1. WEIGHT 5.5 LBS.
  2. POWER DISSIPATION: 80 WATTS AT FULL POWER.
  3. INTERNAL 25MM SHUTTER
  4. M6 THREADED INSERT AVAILABLE FOR CAMERA MOUNTING.
  5. VACUUM WINDOW THICKNESS .125" [3.17mm].

Figure 63. F-Mount: Internal Shutter (Liquid-cooled)

# PIXIS Camera: 2048 F-mount (Air-Cooled)

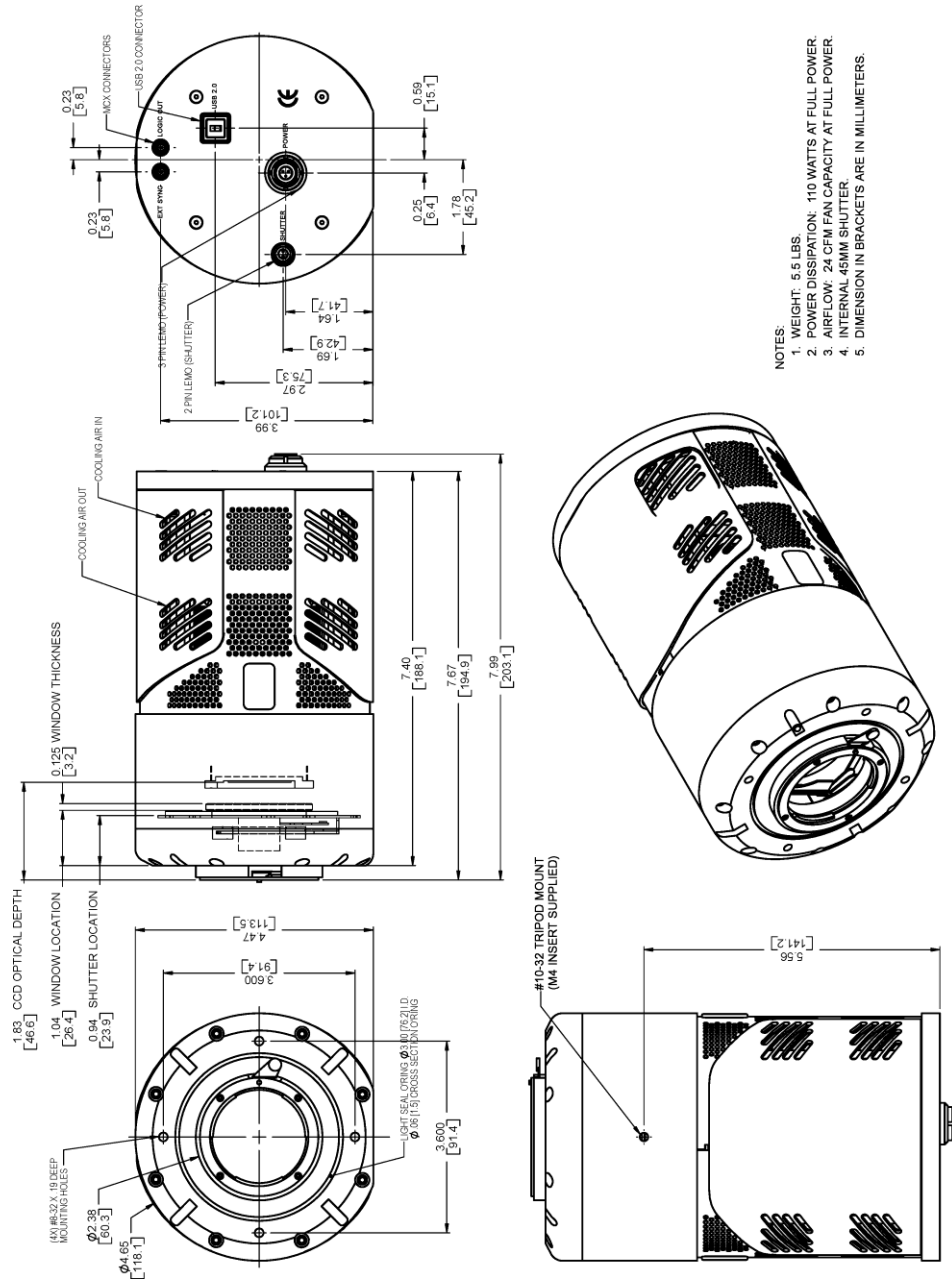


Figure 64. F-Mount: 2048x2048, Internal Shutter (Air-cooled)

# PIXIS Camera: 2048 F-mount (Liquid-Cooled)

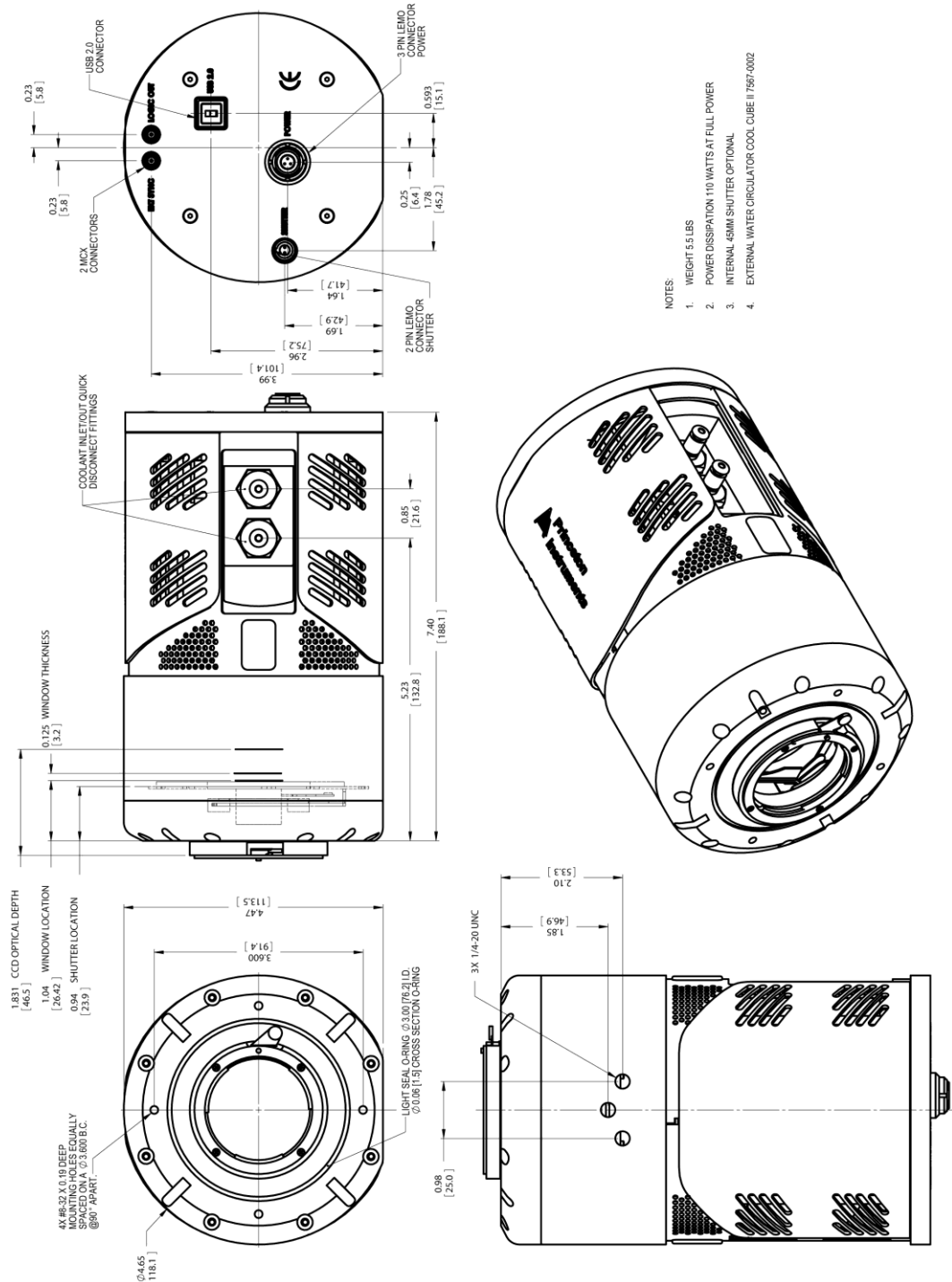


Figure 65. F-Mount: 2048x2048, Internal Shutter (Liquid-cooled)

# PIXIS Camera: Spectroscopy mount (Air-Cooled)

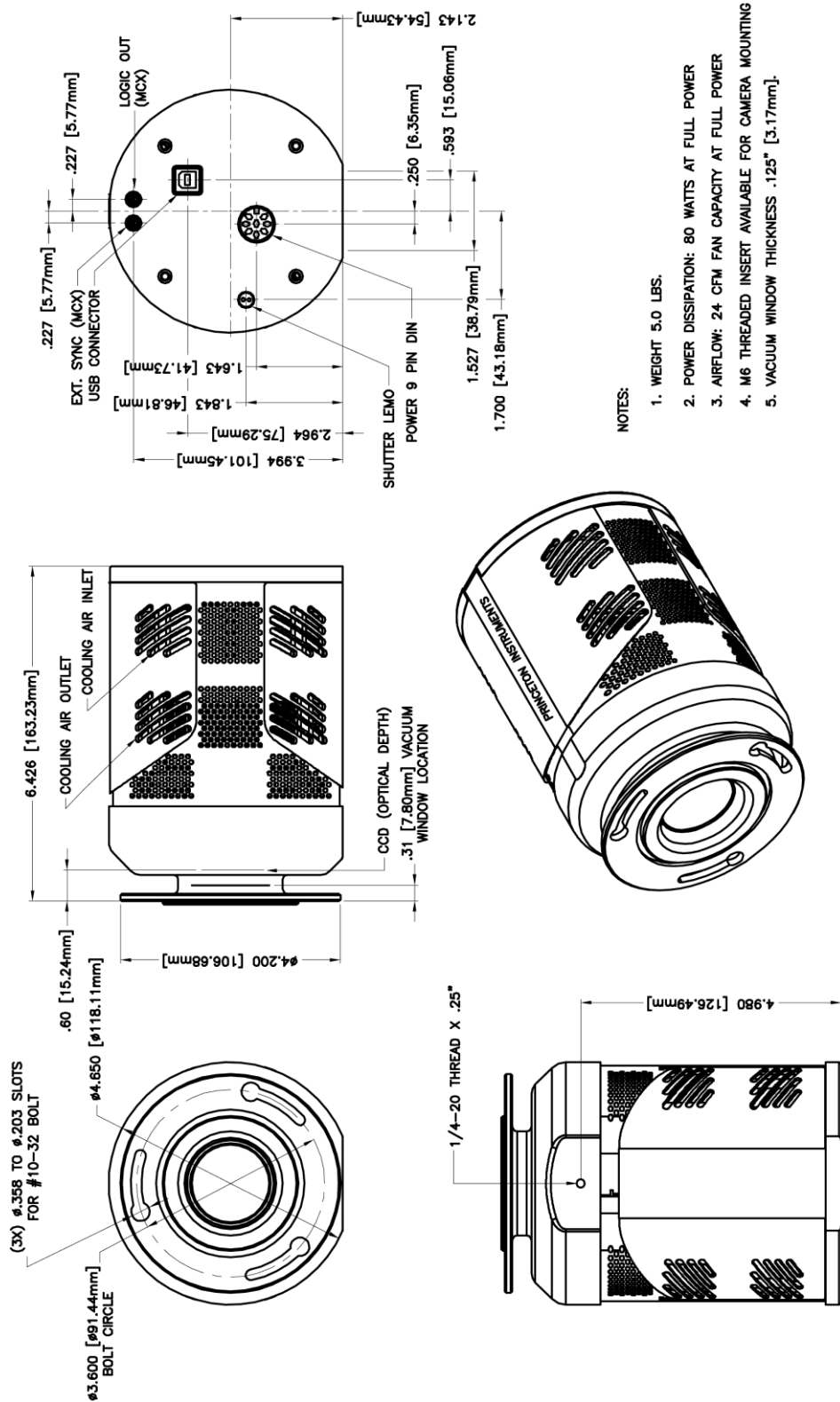


Figure 66. Spectroscopy-Mount: No Internal Shutter, 3.60 bolt circle (Air-cooled)

# PIXIS Camera: Spectroscopy mount (Liquid-Cooled)

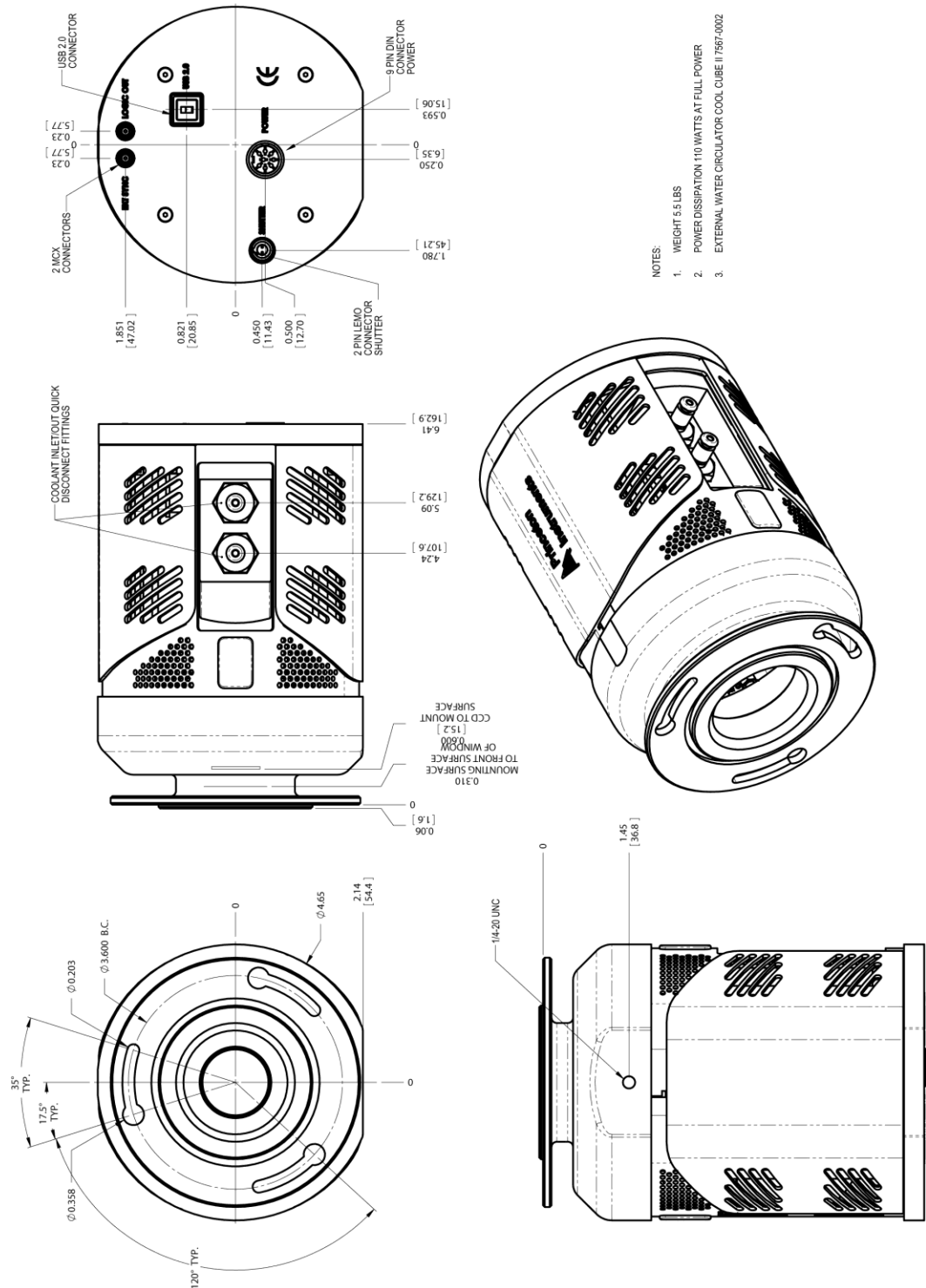


Figure 67. Spectroscopy-Mount: No Internal Shutter, 3.60 bolt circle (Liquid-cooled)



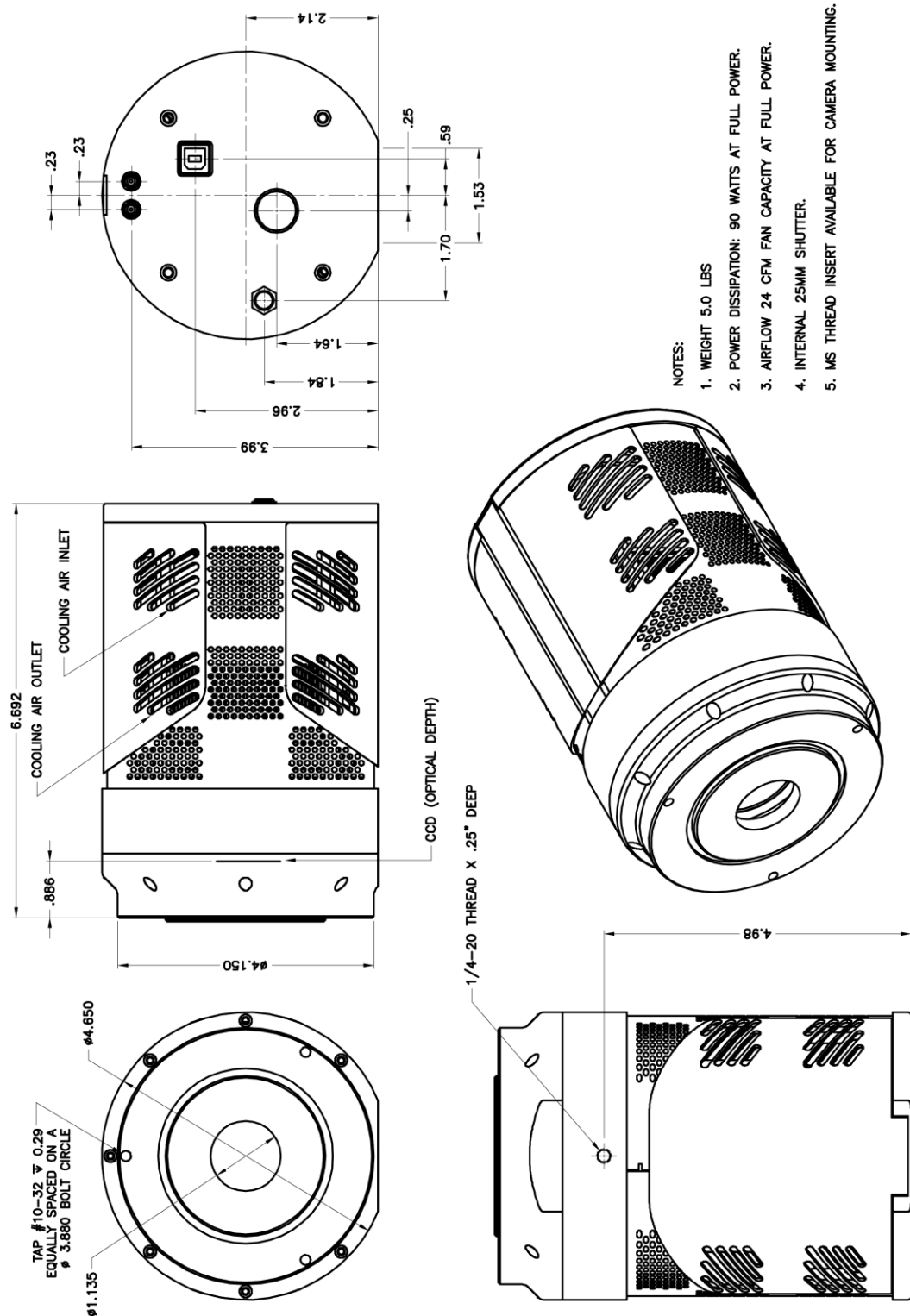


Figure 68. Spectroscopy-Mount: Internal Shutter (3.60" and 3.88" bolt circles) (Air-cooled)

# CoolCUBE<sub>II</sub> Circulator

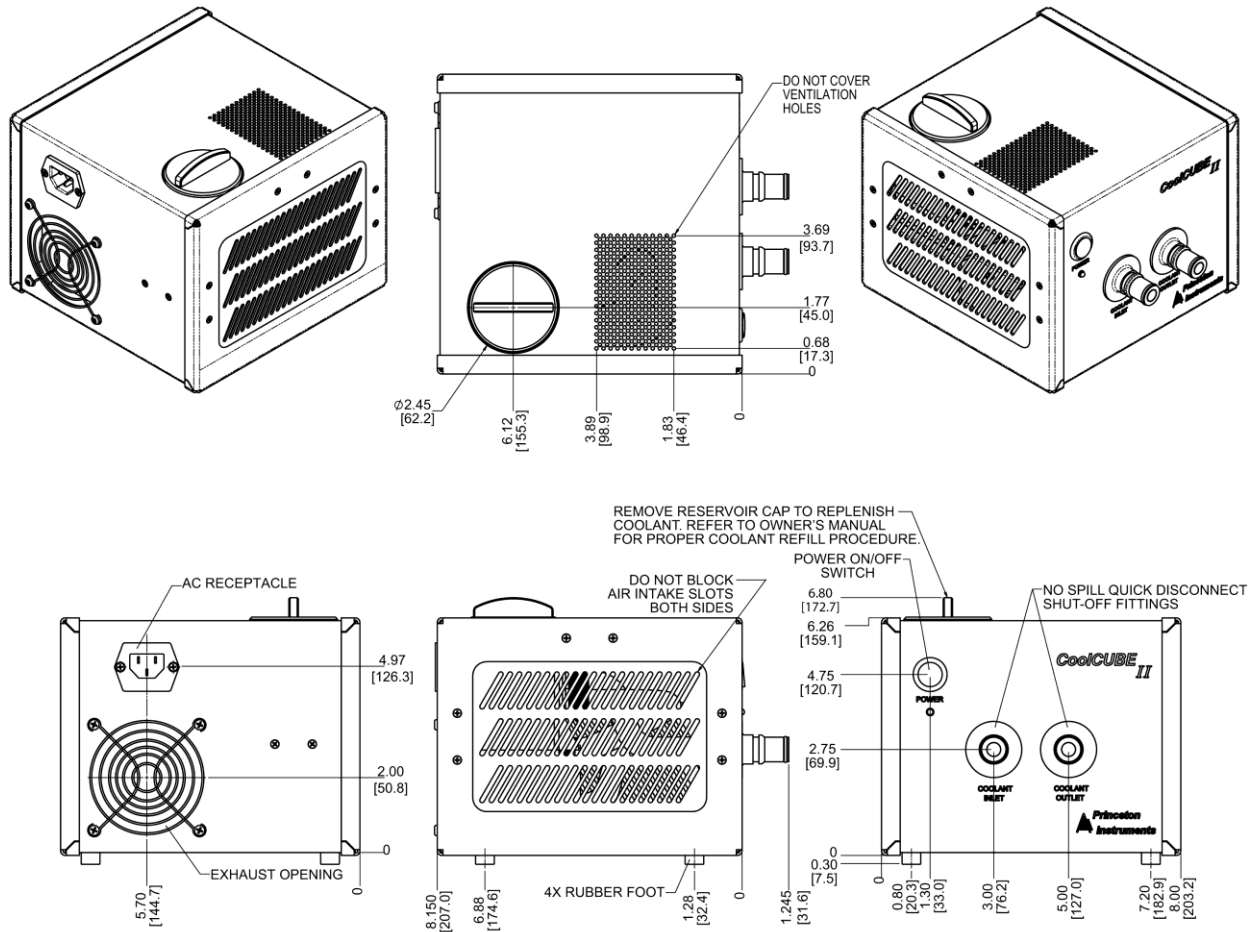


Figure 69. CoolCUBE<sub>II</sub> Circulator

# Appendix C

## Adapter Adjustment and Focusing Procedures

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### Adjustable C-Mount Adapter

PIXIS cameras are now available with an adjustable C-mount adapter. The camera is adjusted at the factory for standard C-mount focusing distance. However, you may want to adjust the focusing distance for your application.

#### **Tools Required**

- Spanner (supplied)
- Small flat blade screwdriver



#### **Procedure**

1. Using a small flat blade screwdriver, loosen the lock screws.
2. Use the spanner to rotate the C-mount adapter the desired distance.
3. Tighten the lock screws to lock the C-mount adapter in place.

**Note:** To tighten down the screws, the face of the adapter should be no further than .06" (1.5 mm) out from the front surface of the camera nose.



#### **Caution**

The C-mount lens thread-depth should be .21" (5.3 mm) or less. Otherwise, depending on the adapter in-out location, the lens could bottom out and damage the shutter, if there is one installed. If you are not certain of the thread depth, remove the adapter from the camera, thread the lens into the adapter until the lens threads are flush with the back surface of the adapter. Note the depth at the front surface, remove the lens, and then re-insert the adapter into the camera nose.

## F-Mount Adapter Focusing Procedure

**Note:** This procedure sets the focus for the F-mount adapter, not the lens. Once set, it should not need to be disturbed again.

1. The lens should be mounted to the camera as described in Chapter 4.
2. The F-mount adapter is in two sections: the adapter body (into which the lens is mounted) and the adapter adjustment ring that is secured to the front of the camera. Try rotating the adapter body. If it doesn't rotate, you will have to loosen the securing setscrew(s) in the side of the adapter adjustment ring. To change the focus setting, proceed as follows.
  - Loosen the setscrew(s) with a 0.050" hex key\*. Do not remove the screw(s); loosen just enough to allow the adapter body to be adjusted.
  - Set the *lens focus adjustment* to the target distance.
3. Block off the lens and set it to the smallest possible aperture (largest F-stop number).
4. Mount a suitable target at a known distance in front of the lens. Typically, a photo resolution chart is used. However, even a page of small print will generally serve quite well for this purpose.
5. Verify that all cables and connectors are secured.
6. Turn on the system and start the **WinView/32** software.
7. Set the software to the **FreeRun** and **Safe** modes (consult the software manual if you are unfamiliar with these modes). Choose a fast exposure (.1 ms) and begin data collection by selecting **Focus**.
8. Slowly uncover the lens. If the image becomes washed out, recover the lens, choose a shorter exposure, and uncover the lens again. If it is too dark, choose a longer exposure.
9. Double check to be sure the *lens focus* is set to the *target distance* and readjust if necessary.
10. Taking care not to disturb the *lens focus*, rotate the *adapter body* for maximum sharpness in the observed image and tighten the setscrews to secure the adapter body's position.

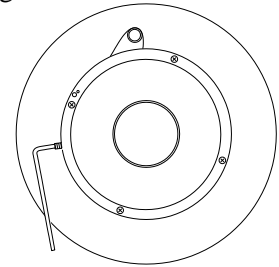


Figure 70. F-mount Adjustment

This completes the procedure for adjusting the *F-mount adapter*. It should not be necessary to disturb the adjustment again. In actual measurements with real subjects, the focusing will be done entirely with the *lens focus adjustment*.

---

\* The screws are #4-40 setscrews. A 0.050" hex key is required to loosen or tighten them.

## Lens Focusing Procedure

Except for the lens mount focus procedure that applies to F-mount lenses as described above, there is no difference between focusing considerations for an F-mount lens and a C-mount lens. Simply use the focusing ring on the lens to produce the sharpest image at full aperture. Then stop the lens down to its sharpest aperture (probably at a mid-range aperture setting) and adjust the Exposure Time for the best possible image as observed at the monitor.

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## Appendix D

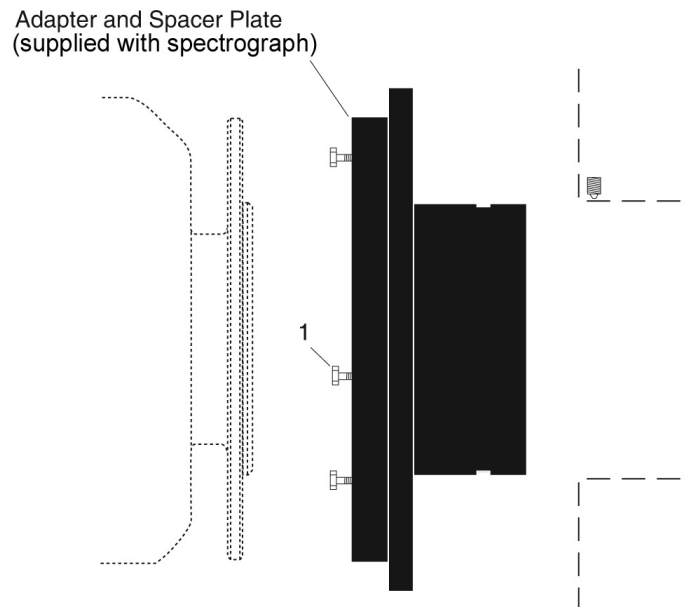
# Spectrograph Adapters

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Princeton Instruments offers a variety of spectrograph adapters for PIXIS systems. The mounting instructions for these adapters are organized by spectrograph model, detector type, and adapter kit number. The table below cross-references these items with the page number for the appropriate instruction set.

<b>Spectrograph</b>	<b>Adapter Kit No.</b>	<b>Page</b>
Acton Series (PIXIS with Flange)		112
Acton Series (PIXIS with 3.60/3.88" Bolt Circles)		113
Acton Series (PIXIS with C-Mount)		114
Acton SP-2350/SP-2550 (PIXIS with adjustable C- to spectroscopy-mount kinetics adapter)	7050-0104	115
Acton SP-2150/SP-2750 (PIXIS with adjustable C- to spectroscopy-mount kinetics adapter)	7050-0107	116
IsoPlane SCT-320 (PIXIS with Flange)		117

## Acton Series Spectrograph (PIXIS with Flange)



Qty	P/N	Description	
1.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel

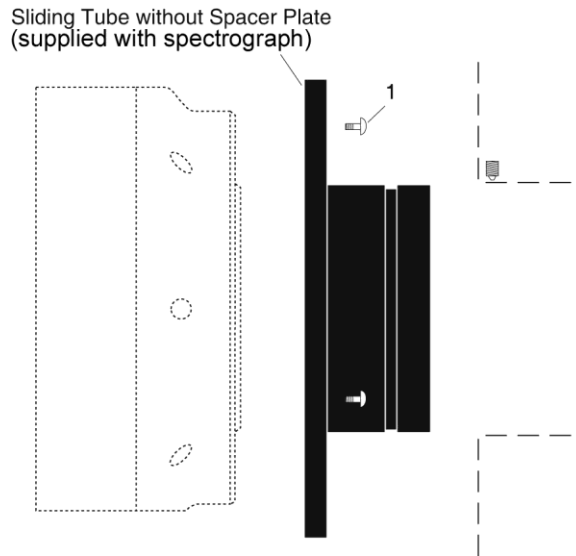
### Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrograph.
2. If the spacer plate has been removed, reinstall it on the sliding tube.
3. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to the sliding tube.
4. Mount the detector flange on the sliding tube assembly and rotate the detector so the screw heads are over the narrow end of the slots.
5. Tighten the screws.

**Note:** Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two setscrews that secure it, and then rotate the tube as you pull it out. If you have removed the sliding tube from the spectrograph, rotate the sliding tube as you re-insert it, and tighten the setscrews afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.



## Acton Series Spectrograph (PIXIS with 3.60/3.88 Bolt Circles)



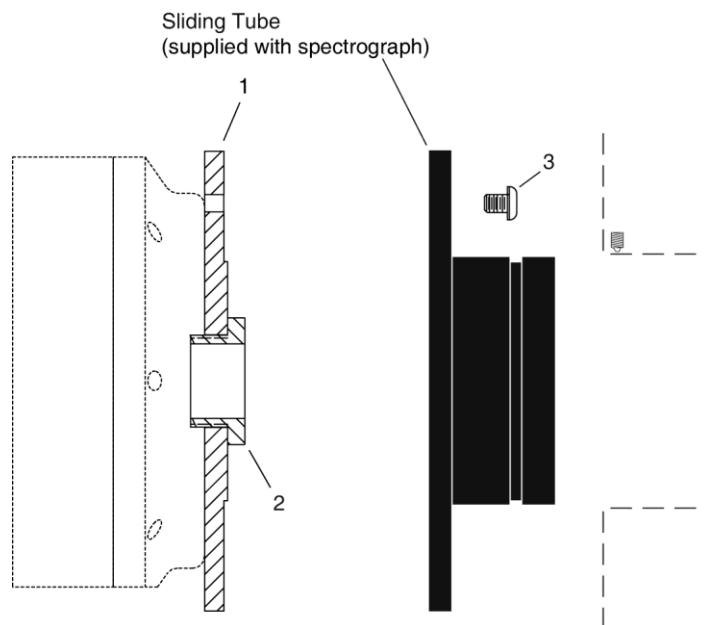
Qty	P/N	Description	
1.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel

### Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrograph.
2. Loosen the setscrews holding the sliding tube in the spectrograph.
3. Rotate the sliding tube as you remove it from the spectrograph.
4. Remove the spacer plate from the sliding tube by removing the three (3) socket head screws.
5. Mount the sliding tube to the detector nose with the three (3) 1/4" long button head screws.
6. Rotate the sliding tube as you gently insert it into the spectrograph.
7. Secure the sliding tube with the setscrews.

**Note:** Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two setscrews that secure it, and then rotate the tube as you pull it out. If you have removed the sliding tube from the spectrograph, rotate the sliding tube as you re-insert it, and tighten the setscrews afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.

## Acton Series Spectrograph (PIXIS with C-Mount)



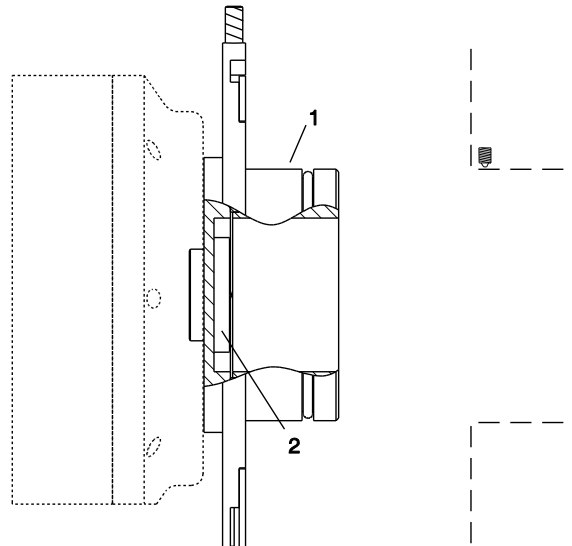
Qty	P/N	Description
1.	1 8401-071-01	Adapter Plate
2.	1 8401-071-02	Threaded C-Mount Adapter
3.	3 2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel

### Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrograph.
2. Loosen the setscrews holding the sliding tube in the spectrograph.
3. Rotate the sliding tube as you remove it from the spectrograph.
4. If there is a spacer plate installed on the sliding tube, remove it.
5. Place the flat side of the adapter plate against the face of the detector.
6. Insert the threaded C-mount adapter through the center hole in the plate and screw the adapter into the detector's C-mount.
7. Using three (3) 1/4" long button head screws, secure the sliding tube to the adapter plate.
8. Rotate the sliding tube as you gently insert it into the spectrograph.
9. Secure the sliding tube with the setscrews.

**Note:** Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two setscrews that secure it, and then rotate the tube as you pull it out. If you have removed the sliding tube from the spectrograph, rotate the sliding tube as you re-insert it, and tighten the setscrews afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.

## Acton SP-2350/SP-2550 Adjustable C- to Spectroscopy-Mount Adapter (Adapter Kit 7050-0104)



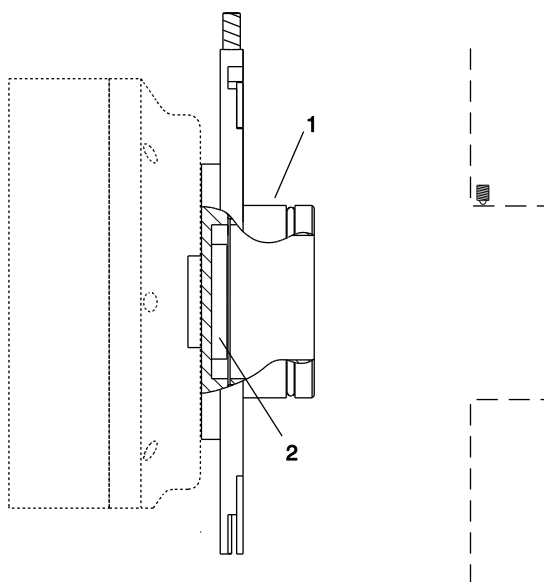
	Qty	P/N	Description
1.	1		Adapter Plate
2.	1	2518-1284	1.25"-32 Threaded Insert

### Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrograph.
2. Place the flat side of the adapter plate against the face of the detector.
3. Insert the threaded insert through the center hole in the plate and screw the adapter into the detector's C-mount.
4. Rotate the sliding tube as you gently insert it into the spectrograph,
5. Secure the sliding tube with the setscrews.

**Note:** Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two setscrews that secure it, and then rotate the tube as you pull it out. If you have removed the sliding tube from the spectrograph, rotate the sliding tube as you re-insert it, and tighten the setscrews afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.

## Acton SP-2150/SP-2750 Adjustable C- to Spectroscopy-Mount Adapter (Adapter Kit 7050-0107)



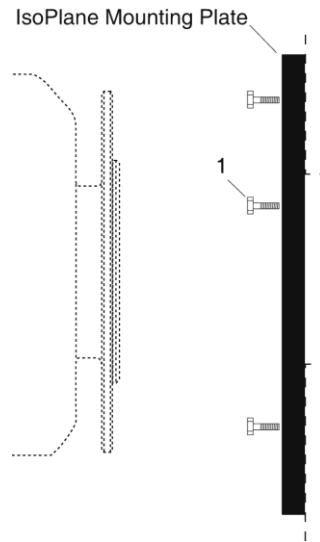
	Qty	P/N	Description
1.	1		Adapter Plate
2.	1	2518-1284	1.25"-32 Threaded Insert

### Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrograph.
2. Place the flat side of the adapter plate against the face of the detector.
3. Insert the threaded insert through the center hole in the plate and screw the adapter into the detector's C-mount.
4. Rotate the sliding tube as you gently insert it into the spectrograph.
5. Secure the sliding tube with the setscrews.

**Note:** Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two setscrews that secure it, and then rotate the tube as you pull it out. If you have removed the sliding tube from the spectrograph, rotate the sliding tube as you re-insert it, and tighten the setscrews afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.

## IsoPlane SCT-320 (PIXIS with Flange)



Qty	P/N	Description	
1.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel

### Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector mounting plate on the IsoPlane.
2. Leaving 1/4" of thread exposed, screw the three (3) hex head screws into the mounting plate.
3. Mount the detector to the mounting plate: the text should be right-reading on the back of the detector.
4. Tighten the three screws with a 5/16" open end wrench.

### Notes:

1. Rotational alignment of the detector to the spectrograph optics is done by loosening and subsequently retightening the screws at the mounting plate corners. The holes are slotted to allow about 4° of rotation.
2. If the IsoPlane was ordered with an internal shutter at the entrance slit, the PIXIS, when connected to the Shutter input on the IsoPlane, can control that shutter. If the PIXIS is using its own internal shutter, the IsoPlane shutter will need to be removed. See the IsoPlane SCT 320 manual for shutter removal instructions.

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# Appendix E

## Cross-Referencing of WinX and LightField Terms

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### WinX-to-LightField

WinX	LightField
Active Rows Parallel to Shift Register	Active Height
Active Shift Register Columns	Active Width
ADC Rate	Speed
ADC Resolution	Bit Depth
Continuous Cleans	Clean Until Trigger
Controller Gain	Analog Gain
Custom Chip	Custom Sensor
Custom Timing	Custom Timing
Disable Pixel Bias Correction (PBC)	N/A
Disabled Closed (Shutter)	Always Closed (Shutter)
Disabled Open (Shutter)	Always Open (Shutter)
Easy Bin	Sensor Readout Region expander functions
Edge Trigger	Trigger Determined By
External Sync	Readout Per Trigger
F.T. Dummies or Frame Transfer Dummies	Active Area: Top Margin
Focus	Preview or Run
Free Run	No Response
Free Run (Kinetics)	No Response
Logic Out	Output Signal
Logic Out: Logic 0	Output Signal: Always Low
Logic Out: Logic 1	Output Signal: Always High
Logic Out: Not Ready	Output Signal: Busy
Logic Out: Not Scan	Output Signal: Not Reading Out
Logic Out: Shutter	Output Signal: Shutter Open

<b>WinX</b>	<b>LightField</b>
Minimum Block Size	Final Section Height
Multiple Trigger (Kinetics)	Shift Per Trigger (Kinetics)
Normal Shutter	Normal (Shutter)
Number of Blocks	Final Section Count
Number of Cleans	Number of Clean Cycles
Number of Strips per Clean	Clean Cycle Height
Post-Dummy Rows Parallel to Shift Register	Active Area: Bottom Margin
Post-Dummy Shift Register Columns	Active Area: Right Margin
Pre-Dummy Rows Parallel to Shift Register	Active Area: Top Margin
Pre-Dummy Shift Register Columns	Active Area: Left Margin
PreOpen (Shutter)	Open Before Trigger (Shutter)
Readout Port	Quality
Shutter Close Compensation Time	Closing Delay
Shutter Control	Shutter Mode
Single Trigger (Kinetics)	Readout Per Trigger
Skip Serial Register Clean (deselected)	Clean Serial Register
Target Temperature	Temperature Setpoint
Timing Mode	Trigger Response
Window Size	Kinetics Window Height



## LightField-to-WinX

LightField	WinX
Active Area: Bottom Margin	Post-Dummy Rows Parallel to Shift Register
Active Area: Left Margin	Pre-Dummy Shift Register Columns
Active Area: Right Margin	Post-Dummy Shift Register Columns
Active Area: Top Margin	F.T. Dummies or Frame Transfer Dummies
Active Area: Top Margin	Pre-Dummy Rows Parallel to Shift Register
Active Height	Active Rows Parallel to Shift Register
Active Width	Active Shift Register Columns
Always Closed (Shutter)	Disabled Closed (Shutter)
Always Open (Shutter)	Disabled Open (Shutter)
Analog Gain	Controller Gain
Bit Depth	ADC Resolution
Clean Cycle Height	Number of Strips per Clean
Clean Serial Register	Skip Serial Register Clean (deselected)
Clean Until Trigger	Continuous Cleans
Closing Delay	Shutter Close Compensation Time
Custom Sensor	Custom Chip
Custom Timing	Custom Timing
Final Section Count	Number of Blocks
Final Section Height	Minimum Block Size
Kinetics Window Height	Window Size
N/A	Disable Pixel Bias Correction (PBC)
No Response	Free Run
No Response (Kinetics)	Free Run (Kinetics)
Normal (Shutter)	Normal Shutter
Number of Clean Cycles	Number of Cleans
Open Before Trigger (Shutter)	PreOpen (Shutter)
Output Signal	Logic Out
Output Signal: Always High	Logic Out: Logic 1
Output Signal: Always Low	Logic Out: Logic 0
Output Signal: Busy	Logic Out: Not Ready

<b>LightField</b>	<b>WinX</b>
Output Signal: Not Reading Out	Logic Out: Not Scan
Output Signal: Shutter Open	Logic Out: Shutter
Preview	Focus
Quality	Readout Port
Readout Per Trigger	External Sync
Readout Per Trigger (Kinetics)	Single Trigger (Kinetics)
Sensor Readout Region expander functions	Easy Bin
Shift Per Trigger (Kinetics)	Multiple Trigger (Kinetics)
Shutter Mode	Shutter Control
Speed	ADC Rate
Temperature Setpoint	Target Temperature
Trigger Determined By	Edge Trigger
Trigger Response	Timing Mode

# Warranty & Service

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## Limited Warranty

Princeton Instruments, a division of Roper Scientific, Inc. ("Princeton Instruments", "us", "we", "our") makes the following limited warranties. These limited warranties extend to the original purchaser ("You", "you") only and no other purchaser or transferee. We have complete control over all warranties and may alter or terminate any or all warranties at any time we deem necessary.

### ***Basic Limited One (1) Year Warranty***

Princeton Instruments warrants this product against substantial defects in materials and / or workmanship for a period of up to one (1) year after shipment. During this period, Princeton Instruments will repair the product or, at its sole option, repair or replace any defective part without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, to a factory-authorized service center. You are responsible for the shipping costs to return the product. International customers should contact their local Princeton Instruments authorized representative/distributor for repair information and assistance, or visit our technical support page at [www.princetoninstruments.com](http://www.princetoninstruments.com).

### ***Limited One (1) Year Warranty on Refurbished or Discontinued Products***

Princeton Instruments warrants, with the exception of the CCD imaging device (which carries NO WARRANTIES EXPRESS OR IMPLIED), this product against defects in materials or workmanship for a period of up to one (1) year after shipment. During this period, Princeton Instruments will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Princeton Instruments. International customers should contact their local Princeton Instruments representative/distributor for repair information and assistance or visit our technical support page at [www.princetoninstruments.com](http://www.princetoninstruments.com).

### ***XP Vacuum Chamber Limited Lifetime Warranty***

Princeton Instruments warrants that the cooling performance of the system will meet our specifications over the lifetime of an XP style detector (has all metal seals) or Princeton Instruments will, at its sole option, repair or replace any vacuum chamber components necessary to restore the cooling performance back to the original specifications at no cost to the original purchaser. *Any failure to "cool to spec" beyond our Basic (1) year limited warranty from date of shipment, due to a non-vacuum-related component failure (e.g., any components that are electrical/electronic) is NOT covered and carries NO WARRANTIES EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

**Sealed Chamber Integrity Limited 12 Month Warranty**

Princeton Instruments warrants the sealed chamber integrity of all our products for a period of twelve (12) months after shipment. If, at anytime within twelve (12) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

**Vacuum Integrity Limited 12 Month Warranty**

Princeton Instruments warrants the vacuum integrity of “Non-XP” style detectors (do not have all metal seals) for a period of up to twelve (12) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twelve (12) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

**Image Intensifier Detector Limited One Year Warranty**

All image intensifier products are inherently susceptible to Phosphor and/or Photocathode burn (physical damage) when exposed to high intensity light. Princeton Instruments warrants, with the exception of image intensifier products that are found to have Phosphor and/or Photocathode burn damage (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all image intensifier products for a period of one (1) year after shipment. *See additional Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

**X-Ray Detector Limited One Year Warranty**

Princeton Instruments warrants, with the exception of CCD imaging device and fiber optic assembly damage due to X-rays (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all X-ray products for one (1) year after shipment. *See additional Basic Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

**Software Limited Warranty**

Princeton Instruments warrants all of our manufactured software discs to be free from substantial defects in materials and / or workmanship under normal use for a period of one (1) year from shipment. Princeton Instruments does not warrant that the function of the software will meet your requirements or that operation will be uninterrupted or error free. You assume responsibility for selecting the software to achieve your intended results and for the use and results obtained from the software. In addition, during the one (1) year limited warranty. The original purchaser is entitled to receive free version upgrades. Version upgrades supplied free of charge will be in the form of a download from the Internet. Those customers who do not have access to the Internet may obtain the version upgrades on a CD-ROM from our factory for an incidental shipping and handling charge. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

### **Owner's Manual and Troubleshooting**

You should read the owner's manual thoroughly before operating this product. In the unlikely event that you should encounter difficulty operating this product, the owner's manual should be consulted before contacting the Princeton Instruments technical support staff or authorized service representative for assistance. If you have consulted the owner's manual and the problem still persists, please contact the Princeton Instruments technical support staff or our authorized service representative. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

### **Your Responsibility**

The above Limited Warranties are subject to the following terms and conditions:

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Princeton Instruments.
2. You must notify the Princeton Instruments factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a "technical issue" with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Princeton Instruments factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Princeton Instruments factory and receive a return authorization number (RMA). Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Princeton Instruments is not responsible for installation, setup, or disassembly at the customer's location.
7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which:
  - has been lost or discarded by you;
  - has been damaged as a result of misuse, improper installation, faulty or inadequate maintenance or failure to follow instructions furnished by us;
  - has had serial numbers removed, altered, defaced, or rendered illegible;
  - has been subjected to improper or unauthorized repair;
  - has been damaged due to fire, flood, radiation, or other "acts of God" or other contingencies beyond the control of Princeton Instruments; or
  - is a shutter which is a normal wear item and as such carries a onetime only replacement due to a failure within the original 1 year Manufacturer warranty.
8. After the warranty period has expired, you may contact the Princeton Instruments factory or a Princeton Instruments-authorized representative for repair information and/or extended warranty plans.
9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.

10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Princeton Instruments' liability exceed the cost of the repair or replacement of the defective product or part.
11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Princeton Instruments factory of purchase, contact your authorized Princeton Instruments representative or reseller, or visit our Support page at [www.princetoninstruments.com](http://www.princetoninstruments.com).

## Contact Information

Roper Scientific's manufacturing facility for this product is located at the following address:

Princeton Instruments  
3660 Quakerbridge Road  
Trenton, NJ 08619 (USA)

Tel: 1-800-874-9789 / 1-609-587-9797

Fax: 1-609-587-1970

Customer Support E-mail: [techsupport@princetoninstruments.com](mailto:techsupport@princetoninstruments.com)

For immediate support in your area, please call the following locations directly:

**North America** 1-800- 899-1144 (toll free) or 1-609-587-9797

**France** +33 (1) 60 86 03 65

**Germany** +49 (0) 89 660 7793

**Japan** +81 (3) 5639 2741

**UK & Ireland** +44 (0) 1628 472 346

**Singapore** +65 6408 6240

**China** +86 10 659 16460

Otherwise, see our Support web page at [www.princetoninstruments.com](http://www.princetoninstruments.com).

An up-to-date list of addresses and telephone numbers is posted on the [www.princetoninstruments.com/Support](http://www.princetoninstruments.com/Support) page. In addition, links on this page to support topics allow you to send e-mail based requests to the Customer Support group.

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