TELEDYNE PRINCETON INSTRUMENTS
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Part of the Teledyne Imaging Group

PyLoN® System User Manual

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www.princetoninstruments.com

Revision History

Issue	Date	List of Changes
Issue 5	March 22, 2019	Issue 5 of this document incorporates the following changes: • Rebranding to Teledyne Princeton Instruments.
Issue 4	April 20, 2016	Issue 4 of this document incorporates the following changes: • Removed the Declaration of Conformity.
Issue 3	October 19, 2015	Issue 3 of this document incorporates the following changes: • Updated Declaration of Conformity; • Updated Warranty information; • Updated Troubleshooting chapter.
Issue 2	March 27, 2013	Issue 2 of this document incorporates the following changes: • Added Registered Trademark symbols; • Added IsoPlane support; • Minor editorial and terminology corrections; • Updated specifications section.
Issue 1	February 1, 2012	This is the initial release of this document.

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Chapter 1: About this Manual

Thank you for purchasing a PyLoN® camera system from Teledyne Princeton Instruments. Since 1981 Teledyne Princeton Instruments has been the legendary name behind the most revolutionary spectroscopy and imaging products for cutting edge research.

Please read the manual carefully before operating the camera. This will help you optimize the many features of this camera to suit your research needs.

If you have any questions about the information contained in this manual, contact the Teledyne Princeton Instruments customer service department. Refer to Contact Information on page 130 for complete contact information.

1.1 Intended Audience

This user manual is intended to be used by scientists and other personnel responsible for the installation, setup, configuration, and acquisition of imaging data collected using an PyLoN system.

This document provides all information necessary to safely install, configure, and operate the PyLoN, beginning with the system's initial installation.

1.2 Related Documentation

Table 1-1 provides a list of related documentation and user manuals that may be useful when working with the PyLoN camera system. To guarantee up-to-date information, always refer to the current release of each document listed.

Table 1-1: Related Documentation

Document Number	Document Title
–	WinSpec/32 User Manual
–	LightField® 6 Online Help
–	PyLoN Camera System Data Sheet

Teledyne Princeton Instruments maintains updated documentation and user manuals on their FTP site. Visit the Teledyne Princeton Instruments FTP Site to verify that the most recent user manual is being used:

ftp://ftp.piacton.com/Public/Manuals/Princeton Instruments

ftp://ftp.piacton.com/Public/Manuals/Acton

1.3 Document Organization

This manual includes the following chapters and appendices:

- Chapter 1, About this Manual
  This chapter provides information about the organization of this document, as well as related documents, safety information, and conventions used throughout the manual.
- Chapter 2, PyLoN® Camera System
  Provides information about the components included with a standard PyLoN camera system, as well as options that are available for purchase from Teledyne Princeton Instruments.
- 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 mounting the camera to a spectrograph and for interconnecting the system components.
- Chapter 5, Operation
  Includes a simple procedure for verifying system operation and discusses operational considerations associated with exposure, readout, and digitization.
- Chapter 6, Advanced Topics
  Discusses standard timing modes (Free Run, External Sync, and Continuous Cleans), Fast and Safe triggering modes, and TTL control.
- Chapter 7, Troubleshooting
  Provides courses of action to take if you should have problems with your system.
- Appendix A, Technical Specifications
  Includes computer, controller and camera specifications.
- Appendix B, Outline Drawings
  Includes outline drawings of the PyLoN cameras and its power supply.
- Appendix C, Spectrograph Adapters
  Provides mounting instructions for the spectrograph adapters available for PyLoN cameras.
- Appendix D, WinX/LightField Cross Reference
  Includes two alphabetically sorted tables (WinX to LightField and LightField to WinX) that cross reference terms used in the two applications.
- Warranty and Service
  Provides the Teledyne Princeton Instruments warranty and customer support contact information.

1.3.1 Conventions Used In this Document

WinX is a generic term for WinSpec/32, WinView/32, and WinXTest application software. Often WinX and LightField use different terms for the same functions or parameters. When a topic pertains to both WinX and LightField, curly brackets { } are used to denote a LightField term or location.

Refer to Table 1-2 for the conventions utilized throughout this document.

Table 1-2: Terminology Conventions Used

Topic	Convention Used
WinX-Specific Topic	WinX Term/Location
LightField-Specific Topic	LightField Term/Location
WinX and LightField Shared Topic	WinX Term/Location {LightField Term/Location}

1.4 Safety Related Symbols Used in this Manual

CAUTION!

A **Caution** provides detailed information about actions and/or hazards that may result in damage to the equipment being used, including but not limited to the possible loss of data.

WARNING!

A Warning provides detailed information about actions and/or hazards that may result in personal injury or death to individuals operating the equipment.

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.

1.5 PyLoN Safety Information

Before turning on the power supply, 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.

WARNINGS!

1. If the PyLoN camera system is used in a manner not specified by Teledyne Princeton Instruments, the protection provided by the equipment may be impaired.
2. If the equipment or the wall outlet 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.

1.6 Precautions

To prevent permanently damaging the PyLoN system, observe the following precautions at all times.

1.6.1 General Precautions

1. 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.
2. When using high-voltage equipment (e.g., an arc lamp,) with the camera system, be sure to turn the camera power ON LAST and turn the camera power OFF FIRST.
3. When turning off and on the power supply, wait at least 10 seconds before switching it on. The "SHUTTER FAULT" LED will be lit until the application software initializes the camera. Ignore the LED status if there is no shutter.
4. Use caution when triggering high-current switching devices near the system (e.g., an arc lamp.) 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.
5. Do not block air vents on the camera. Preventing the free flow of air overheats the camera and may damage it.
6. If the PyLoN camera system is used in a manner not specified by Teledyne Princeton Instruments, the protection provided by the equipment may be impaired.

1.6.2 Camera Related Precautions

1. 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. Never impede airflow through the equipment by obstructing the air vents. Allow at least one-inch air space around any vent.
2. Prevent array saturation while data is not being acquired by completely closing the entrance slit to the spectrometer (especially when a shutter is not used.)
3. Protect a UV-scintillator-coated CCD from excessive exposure to UV radiation. This radiation slowly bleaches the scintillator, reducing sensitivity.
4. If an LN-cooled camera is being operated under high humidity conditions, periodically clean the outside of the valves so ice buildup does not prevent the valves from venting normally.

1.6.3 Shutter Related Precautions

To prevent damage to the shutter or shutter drive circuitry, always turn the controller off before connecting or disconnecting the shutter cable.

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Chapter 2: PyLoN® Camera System

This chapter provides an introduction to, and overview information about, Teledyne Princeton Instruments's PyLoN camera system. Figure 2-1 shows those items that are typically included as part of a standard PyLoN camera system.

Figure 2-1: Typical PyLoN System Components

All PyLoN systems consist of standard hardware and software as well as appropriate interface hardware for your computer system. Some systems also include optional hardware.

Optional items include an internal shutter and spectrograph mount adapters.

2.1 PyLoN Camera

The PyLoN family of cameras incorporates performance-optimized spectrometric CCDs, ultra-low-noise electronics, and full software control of both camera and spectrograph to produce a detection system that delivers the data you need. A PyLoN system can be configured with a number of front- and back-illuminated scientific-grade CCDs (including eXcelon® enabled back-illuminated CCDs) that are available only from Teledyne Princeton Instruments. These exclusive cameras, developed jointly with CCD manufacturers, employ several design features engineered specifically towards optimizing performance parameters for spectroscopic experiments. The most obvious special characteristic, the rectangular array format of the CCDs, serves the dual purpose of providing fast spectral rates (small heights) and full spectral coverage (large widths).

Figure 2-2: Typical PyLoN Camera

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2.1.1 eXcelon®

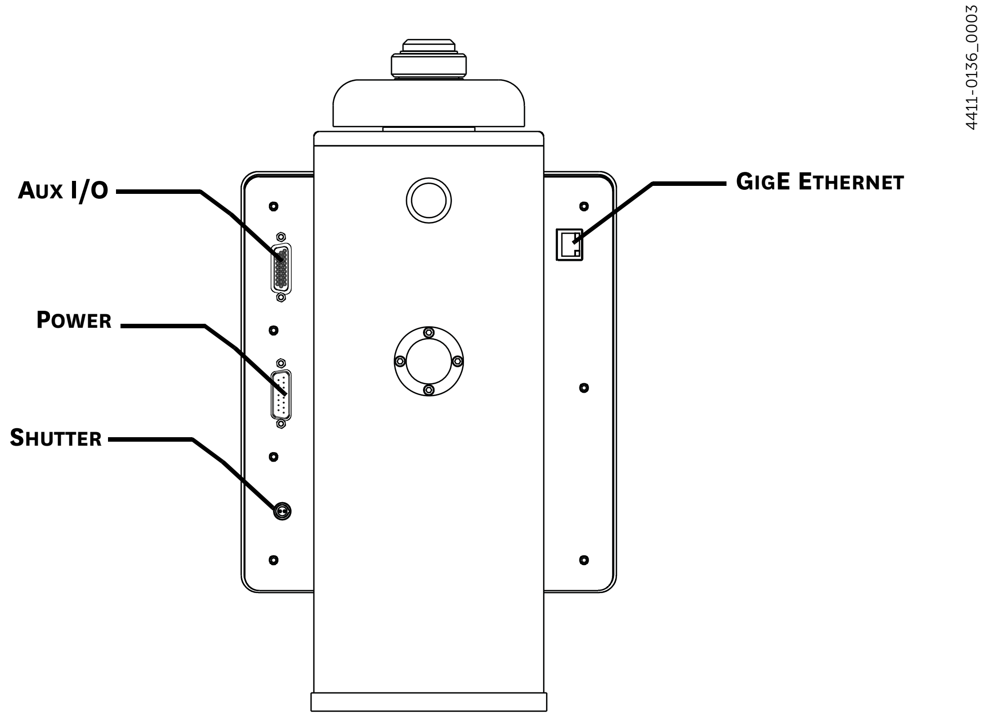
eXcelon is a new sensor technology jointly developed by Teledyne Princeton Instruments, Teledyne e2v, and Teledyne Photometrics. CCDs using this technology provide three significant benefits:

- 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.

2.1.2 PyLoN Rear Panel Connectors

Figure 2-3 illustrates the PyLoN rear-panel connectors.

Figure 2-3: PyLoN Rear Panel Connectors



Refer to Table 2-1 for information about each of the rear panel connectors.

Table 2-1: PyLoN Rear Panel Connectors

Label	Description
GigE	Gigabit Ethernet connector. Used with the Cat 5e/6 Gigabit Ethernet cable (supplied) interconnecting the camera and the GigE interface card in the host computer. A high quality cable must be used to preserve data integrity during transmission. The cable can extend the distance between camera and the host computer by more than 50 m.
Shutter	LEMO connector for driving an internal shutter. Stop data acquisition before connecting to or disconnecting from this connector.
AUX I/O	The AUX I/O connector provides access to the TRIGGER IN, TTL OUT, READOUT MON, EXPOSE MON, and SHUTTER MON I/O signals. Note that the output of the TTL OUT BNC is user-selectable in the software.
Power	Input for shutter power, +16 V_{DC}, -16 V_{DC}, +5.9 V_{DC}, -5.9 V_{DC}, +4.3 V_{DC} power supplies. Also used for the Shutter High Voltage Control signal.

2.1.3 CCD Array

The PyLoN system can be configured with a number of high performance, rectangular-format, front- and back-illuminated scientific grade CCDs (including eXcelon enabled back-illuminated CCDs,) some of which are exclusive to Teledyne Princeton Instruments. The arrays employ several design features engineered specifically towards optimizing performance parameters for spectroscopic experiments.

To raise the QE of these spectroscopic CCDs, Teledyne Princeton Instruments offers a variety of enhancement coatings. For higher sensitivity in the NIR, deep-depletion devices are also available. Teledyne Princeton Instruments has even worked with a device manufacturer to successfully minimize the etaloning effect (fringing) that typically occurs when back-illuminated CCDs are used for NIR spectroscopy. This reduction is accomplished by manufacturing the CCD on thicker silicon, applying an AR coating optimized for NIR, and processing the back surface in a proprietary way that helps break up etaloning.

2.1.4 Window

The PyLoN camera incorporates a single fused silica vacuum window.

2.1.5 Internal Shutter

LN-cooled PyLoN cameras can incorporate an internal shutter. It is important to realize the limitations of the shutter, including its mechanical lifetime (typically one million cycles or more). Avoid running the shutter unnecessarily and avoid using shorter exposure time and higher repetition rates than are required. If a shutter does stop working, contact the factory.

The shutter housing has a quartz shutter window unless otherwise specified. This window protects the shutter mechanism from external dust and humidity. However, a shutter window also causes a small signal loss. If this loss is significant, contact the factory to see if a windowless shutter housing is available. When there is no window, added caution must then be used in the handling and storage of the camera.

2.1.6 Dewar

The Dewar holds 1.7 liters of liquid nitrogen (LN).

2.1.7 Adapters

A variety of spectrograph adapters are available from Teledyne Princeton Instruments. Refer to Appendix C, Spectrograph Adapters, for information about mounting these adapters to your spectrograph and camera.

2.2 Cables

Refer to Table 2-2 for information about the cables that are included with a standard PyLoN camera system.

Table 2-2: Standard PyLoN Camera System Cables

Cable	Part Number	Description/Purpose	Length
Ethernet Cable	6050-0621	Cat 5e/6 Ethernet cable for interconnecting the camera and the host computer. The distance between the camera and the computer can be over 50 meters. Please contact the factory for longer cables.  4411-0136_0004	5 m [16.4 ft]
AUX I/O	6050-0681	Provides TTL outputs and inputs for synchronization with external devices. Inputs must be at least 2.4 V_{DC} for a TTL high and less than 0.9 V_{DC} for a low.  4411-0136_0005	—
Power Cable	6050-0673	The power cable connects the PyLoN camera to its power supply.  4411-0136_0006	3 m [9.8 ft]

2.3 Spectrograph Support

Teledyne Princeton Instruments offers extensive support for spectrograph integration, including fiberoptic accessories, lenses, lens mounts, f# matchers, and spectrograph flanges. The PyLoN camera can be coupled to the entire line of Teledyne Acton Research Series spectrographs and the non-shuttered version can be coupled to the IsoPlane spectrograph. The result is a fully integrated instrument that offers automated software control of both spectrograph and camera.

2.4 Enhancement Coatings

To raise the QE of these spectrometric CCDs, Teledyne Princeton Instruments offers a variety of enhancement coatings. For higher sensitivity in the NIR, deep-depletion devices are also available. Teledyne Princeton Instruments has even worked with a device manufacturer to successfully minimize the etalon effect (fringing) that typically occurs when back-illuminated CCDs are used for NIR spectroscopy. This reduction is accomplished by making the back-illuminated CCD on thicker silicon, applying an AR coating optimized for the NIR, and processing the back surface in a proprietary way that helps break up the etalon effect.

2.5 Certificate of Performance

Each PyLoN camera is shipped with a Certificate of Performance which states that the camera system has been assembled and tested according to approved Teledyne Princeton Instruments procedures. It documents the camera's performance data as measured during the testing of the PyLoN and lists the following camera- and customer-specific information:

- Sales Order Number;
- Purchase Order Number;
- Camera Serial Numbers

This information is useful when contacting Teledyne Princeton Instruments Customer Support.

2.6 Application Software

PyLoN cameras run under both WinSpec/32, Teledyne Princeton Instruments' 32-bit Windows® software for spectroscopy and LightField®, Teledyne Princeton Instruments' 64-bit Windows Vista® and Windows® 7 software. These software applications provide comprehensive spectral acquisition, display, processing, and archiving functions — so complete data acquisition and analysis can be performed without having to rely upon third-party software. Automatic spectrometer control and calibration routines can be run, as well as moving to any spectral window or changing gratings without having to recalibrate. PVCAM® (32-bit) and PICam™ (64-bit) allow customers to write custom own software, making integration of the detection system into larger experiments or instruments a straightforward endeavor.

- WinX

  The PyLoN camera can be operated by using WinSpec/32, Teledyne Princeton Instruments' 32-bit Windows® software package designed specifically for high-end spectroscopy. The Teledyne 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. WinSpec takes advantage of the versatility of the PyLoN camera and even enhance it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

- LightField

  The PyLoN camera can be operated using LightField, Teledyne Princeton Instruments 64-bit Windows Vista® and Windows® 7 compatible software package. LightField combines complete control over Teledyne 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.
- PVCAM

  The standard 32-bit software interface for cooled CCD cameras from Teledyne 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.
- PICam

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

  A collection of LabVIEW® VIs for scientific cameras and spectrographs. This third party software can be purchased from Teledyne Princeton Instruments.

2.7 PyLoN Camera and System Maintenance

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.

2.7.1 Camera

Although there is no periodic maintenance that must be performed on the PyLoN 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 also they could damage the finish of the surfaces on which they are used.

2.7.2 Optical Surfaces

Optical surfaces may need to be cleaned 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.

2.7.3 Repairs

Other than the two fuses in the external power supply, there are no user-serviceable parts. Any repairs (other than fuse replacement) must be done by Teledyne Princeton Instruments. Should your system need repair, contact Teledyne Princeton Instruments customer service for instructions. Refer to Contact Information on page 130 for complete information.

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

Chapter 3: Installation Overview

Table 3-1 provides a high-level sequence of actions required to connect a PyLoN camera system and prepare to gather data.

Figure 3-1 and Figure 3-2 illustrate typical system diagrams.

Table 3-1: PyLoN Installation Instructions (Sheet 1 of 2)

Installation Step	Refer to:
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.	Section 4.1, Unpack the System, on page 27
2. Verify that all system components have been received.	Section 4.2, Verify Equipment and Parts Inventory, on page 27
3. If the components show no signs of damage, verify that the appropriate power cord has been supplied with the power supply.	Section 4.2, Verify Equipment and Parts Inventory, on page 27
4. WinSpec/32: If the Ethernet adapter card provided with the system is not already installed in the host computer, install it. LightField: If there is an unused Ethernet connector on the host computer, you can use it for communication and data transfer. If there is no available Ethernet connector, install the Ethernet card provided with the PyLoN system.	Refer to the interface card manufacturer's information.
5. If the application software is not already installed in the host computer, install it.	Section 4.3, Install the Application Software, on page 28 Software manual
6. Mount the camera to the spectrograph.	Section 4.4, Mount PyLoN to a Spectrograph, on page 30
7. With the power supply disconnected from the camera, connect the Ethernet cable to the GigE connector on the rear of the camera and to the Ethernet port on the installed Ethernet card.	—
8. Connect the power supply to the camera.	—
9. Turn the power supply on.	—
10. Turn on the computer and begin running the application software.	Software manual
11. Enter the hardware and experiment setup information.	Software manual
12. Set the target array temperature.	Section 5.3.3.1, CCD Temperature Control, on page 61

Table 3-1: PyLoN Installation Instructions (Sheet 2 of 2)

Installation Step	Refer to:
13. Fill the Dewar.	Section 4.7, Fill the Dewar, on page 35
14. When the system reaches temperature lock, wait an additional 30 minutes and then begin acquiring data in focus mode.	—
15. Adjust the focus for the best spectral lines. If you are running WinSpec/32, you may want to use the Focus Helper function for this purpose. If you are running LightField, you may want to use the Alignment Helper function.	WinX: Section 5.1.4, Rotational Alignment and Focusing, on page 44 Section 5.2.3, Rotational Alignment and Focusing, on page 52

3.1 System Diagrams

Figure 3-1: System Diagram: PyLoN with Teledyne Acton Research Series Spectrograph

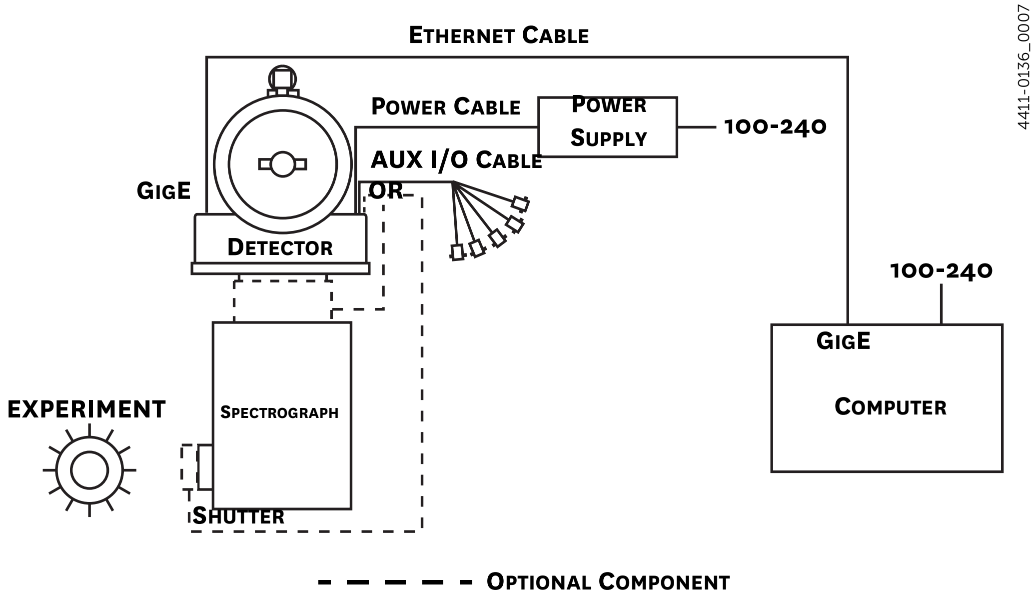
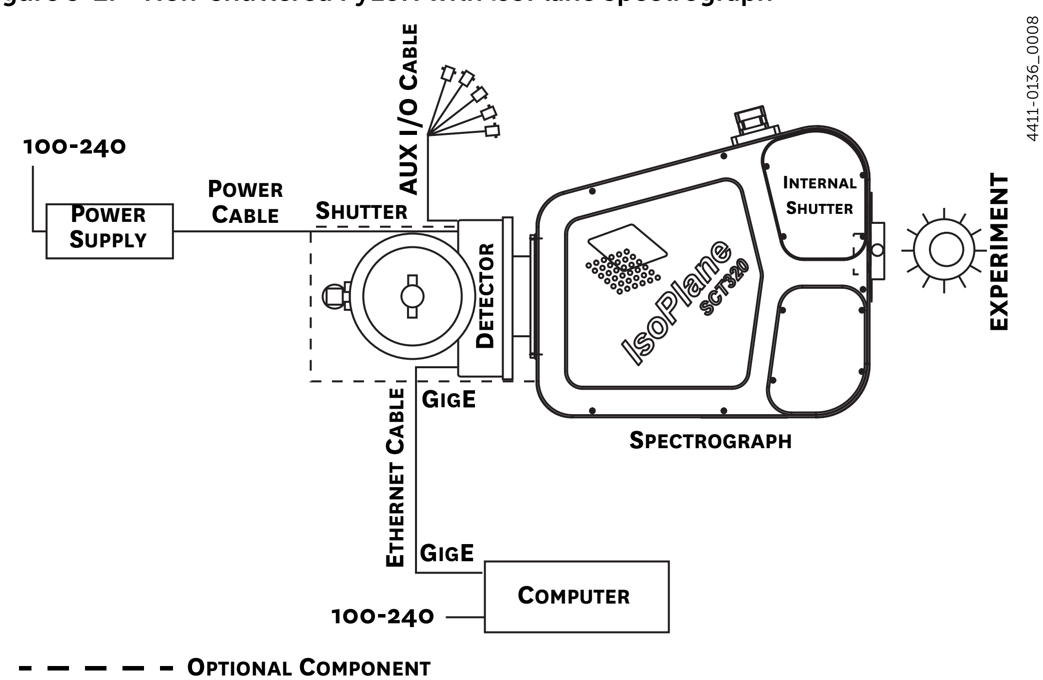


Figure 3-2: Non-Shuttered PyLoN with IsoPlane Spectrograph



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Chapter 4: System Setup

This chapter provides information about the initial system setup for a PyLoN camera system.

4.1 Unpack the System

All required items should be included with the shipment. The PyLoN system has been manufactured according to the camera options specified at the time of purchase, including the CCD window and coatings that were ordered.

When unpacking the system, examine the system components for any signs of shipping damage. If there are any, notify Teledyne Princeton Instruments immediately and file a claim with the carrier. Be sure to save the shipping carton for inspection by the carrier. If damage is not apparent but system specifications cannot be achieved, internal damage may have occurred in shipment.

Retain all original packing materials so that the PyLoN system can be easily and safely packaged and shipped to another location or returned for service if necessary. If assistance is required at any time, contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 130 for complete information.

4.2 Verify Equipment and Parts Inventory

Verify all equipment and parts required to set up the PyLoN system have been delivered.

A typical system consists of:

- PyLoN Camera and Power Supply
- Host Computer

  May be purchased from Teledyne Princeton Instruments or provided by user. For enhanced performance, a fast hard drive (10,000 rpm) and 2GB RAM is recommended.
- Operating System:
  - WinSpec/32: Windows XP (32-bit, SP3 or later) or Vista (32-bit).
  - LightField: Windows Vista (64-bit) or Windows 7 (64-bit).
- Interface Card: Intel® PRO/1000 card is supplied with the system.
- GigE cable: DB9 to DB9 cable (6050-0148-CE is standard)
- PyLoN System User Manual

Accessories that may have been purchased include:

- External Shutter(s).
- Application Software:
  - WinSpec32 (Version. 2.6.5 or later) CD-ROM (optional)
  - LightField CD-ROM (optional)
  - Software User Manual (provided with application software)

4.3 Install the Application Software

This section provides information about installing the image acquisition software.

4.3.1 Install WinX

NOTES:

1. Install the GigE Adapter card BEFORE installing the WinX application software.
2. Leave the interface cable disconnected from the camera until WinX (Version. 2.6.5 or later) has been installed.

Perform the following procedure to install WinX:

1. Insert the CD and follow the installation wizard prompts.
2. On the **Select Installation Type** dialog select:
   - **Typical** to install the required drivers and the most commonly installed program files;
   - **Custom** to select among the available program files or do not want to install the drivers;
   - **Complete** to install all application features.

   See Figure 3.
3. **Verify** the camera is connected to the host computer and that the camera power supply is turned on.
4. Reboot the computer.
5. At boot up, Windows will detect the GigE card.

4.3.2 Install LightField

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

Before starting the installation:

- Verify that the computer operating system is Windows Vista (64-bit) or Windows 7 (64-bit).
- Confirm that the Pro 1000 interface card has been installed in your computer.
- Verify that your computer is connected to the Internet. Internet connection is required for product activation.

Perform the following procedure to install LightField:

1. Insert the CD and follow the installation wizard prompts.

Figure 4-1: Typical LightField Installation Wizard Dialog

4411-0136_0010

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

4.4 Mount PyLoN to a Spectrograph

The camera must be properly mounted to the spectrograph to take advantage of all the available grouping features. Depending on the spectrograph and camera type, special adapters may be required to mount the camera to the spectrograph. The appropriate adapters should have been included with your system if the spectrograph type was indicated when the system was ordered.

Because of the many possible PyLoN camera and spectrograph combinations, all adapter mounting instructions are provided in Appendix C, Spectrograph Adapters, on page 115. Refer to the table at the beginning of that appendix to identify the instruction set appropriate to your system.

WARNING!

An LN-cooled camera must never be tilted more than 30° from vertical unless an all-directional Dewar option has been purchased. If mounting the Dewar to your system requires you to exceed the 30° limit, you may have the wrong type of Dewar. Contact the factory. Refer to Contact Information on page 130 for complete information.

4.4.1 Focal Plane Distance

The distance to the focal plane from the front of the mechanical assembly depends on the specific configuration as listed in Table 4-1.

Table 4-1: Focal Plane Distances

Cooling	Reference Points	Distance
LN	Front of Shutter Housing to Focal Plane	0.894 ± 0.01"
LN	Front of Non-Shutter Housing to Focal Plane	0.549 ± 0.01"

NOTE:

The shutter housing has a 3.88" bolt circle. The housing for a camera without an internal shutter has a 3.60^2 bolt circle.

4.4.2 Optical Center of the Array

An LN-cooled camera shrinks when the Dewar is filled with LN and the camera cools down to operating temperature. For side-on Dewars, the optical center of the CCD shifts towards the fill port by approximately 0.035" (0.889 mm) with respect to the nose. Because of this, an image area or a focus set at room temperature will change as a camera cools.

The PyLoN camera is designed so the optical center of a CCD is offset at room temperature. Therefore, when the camera cools to its operating temperature, the optical center of the CCD is at the center of the nose.

4.4.3 Array Orientation

All users with rectangular CCDs must first determine the correct orientation of the camera.

All cameras must be mounted in the correct orientation to take advantage of the many hardware and software features. The camera should be mounted so that the short axis of the CCD is parallel to the entrance slit. The long axis will therefore correspond to the wavelength axis of the spectrum, for maximum resolution.

If there is no shutter (internal or external), the simplest way to determine the long and short axes of the CCD is to make a visual inspection of the faceplate. The faceplate cutout closely corresponds to the dimensions of the underlying CCD array, which will itself be visible through the window.

Perform the following procedure to determine the orientation of a CCD when an internal shutter is installed:

1. Turn on the camera's power.
2. Open the shutter as indicated according to the image acquisition software being used:
   - WinX
     Select the Shutter Disabled Open mode in the software.
   - LightField
     Select the Always Open shutter mode.
3. Look in the front window of the CCD to determine the long axis of the CCD.

   NOTE:
   Exposure to room light will not damage the CCD.

   See Figure 4-2.

Figure 4-2: Rectangular CCD Array Orientation

4411-0136_0011

4.4.4 Camera-Spectrograph Adapters

Teledyne Princeton Instruments has a variety of adapters for mating PyLoN cameras to spectrographs. In some situations, the appropriate adapter is mounted to the camera before the camera is shipped from the factory. In other situations, an adapter kit, containing mounting hardware and adapter(s), is shipped with the camera. Refer to Appendix C, Spectrograph Adapters. on page 115 for complete installation information.

4.5 Shutter Configuration

Standard LN-cooled PyLoN cameras do not include internal shutters. However, an optional 40 mm internal shutter is available for LN-cooled cameras and must be specified when ordering the camera.

NOTE:

If using a camera without an internal shutter, a Teledyne Princeton Instruments 25 mm external shutter may be purchased that is typically used at the entrance slit of a spectrograph. However, a standalone program is required to set up the shutter.

4.5.1 Internal Shutter

Because the camera and its internal shutter are shipped as a system, the default shutter type (on the **Hardware Setup ► Controller/Camera** tab in WinX) should not need to be changed.

Perform the following procedure to configure a 40 mm internal shutter:

1. Turn off the camera's power supply.
2. Remove the twist tie from the shutter cable.
3. Connect the shutter cable to the **Shutter** connector on the back of the PyLoN's electronics box.
4. Turn on the camera's power supply.
5. Launch WinX and navigate to the **Hardware Setup ► Controller/Camera** tab.
6. Verify that the selected **Shutter Type** is **Large**.
   The shutter open and shutter close compensation times for this shutter are both approximately 28 ms.

4.5.2 External Shutter

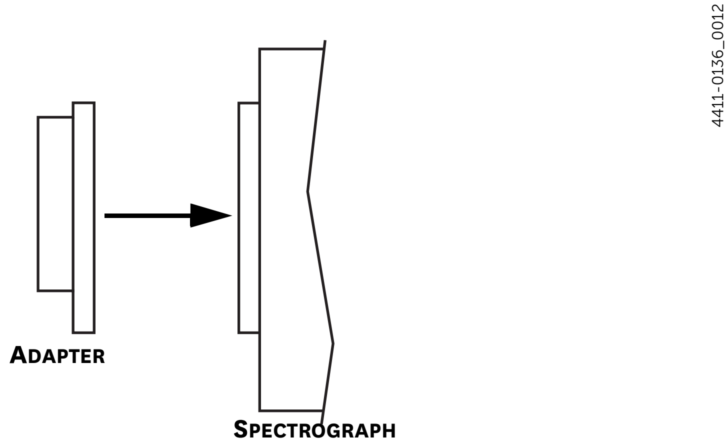
NOTE:

A standalone program is required to configure the shutter.

Perform the following procedure to configure a Teledyne Princeton Instruments-supplied 25 mm external shutter:

1. Verify that the camera's power supply is off.
2. Bolt the entrance slit shutter assembly to the entrance slit of the spectrograph.
   The entrance slit shutter mount used with Teledyne Acton Research Series spectrographs requires no disassembly. See Figure 4-3.

Figure 4-3: Typical Entrance Slit Shutter Mount



3. Connect the shutter cable to the **Shutter** connector on the back of the PyLoN's electronics box.
4. Turn on the camera's power supply.
5. Launch WinX and navigate to the **Hardware Setup** ► **Controller/Camera** tab.
6. Configure **Shutter Type** as **Remote**.
   The shutter compensation time for this shutter is approximately 8 ms.

4.6 Configure Default Camera System Parameters

This section provides information about configuring default system parameters.

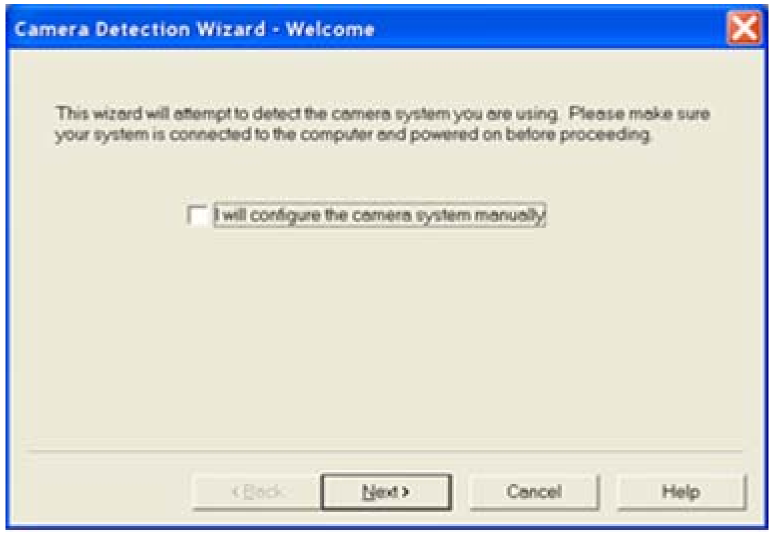
4.6.1 Configure Default WinX System Parameters

Perform the following procedure to configure WinX with default system parameters:

1. Make sure the camera is connected to the host computer and that the camera's power supply is turned on.
2. Open the WinX application software. The Camera Detection wizard will automatically run if this is the first time you have installed a Teledyne Princeton Instruments WinX application (WinSpec/32, WinView/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 launch the wizard.

3. On the **Welcome** dialog leave the checkbox unselected and click on Next. See Figure 4-4.

Figure 4-4: Typical Camera Detection Wizard Dialog: Welcome



4411-0136_0013

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:

Refer to Section 5.1, WinX First Light Instructions, on page 40 for step-by-step information about basic system operation.

4.6.2 Configure Default LightField System Parameters

Perform the following procedure to configure LightField with default system parameters:

1. Verify that the PyLoN and spectrograph (if appropriate) are connected to the host computer and that the camera and spectrograph power supplies are turned on.
2. Launch LightField.
3. While LightField is starting up, it will detect the available device(s) and load the appropriate icons into the **Available Devices** region within the **Experiment** workspace.
4. When an icon is dragged into the **Experiment Devices** area, the appropriate expanders will be loaded into the **Experiment Settings** stack on the left-hand side of the window.

NOTE:

Refer to Section 5.2, LightField First Light Instructions, on page 48 for step-by-step information about basic system operation.

4.7 Fill the Dewar

WARNINGS!

1. Even minimal contact with LN can cause severe injury to eyes and skin. Avoid contact with the splashing that will invariably accompany pouring LN into a room temperature Dewar.
2. Always be careful when removing the Dewar port cap if there is LN present in the Dewar. Pressure due to nitrogen gas can cause the cap to fly out when the retaining nut is loosened, possibly spraying you with liquid LN, which can cause severe injury.

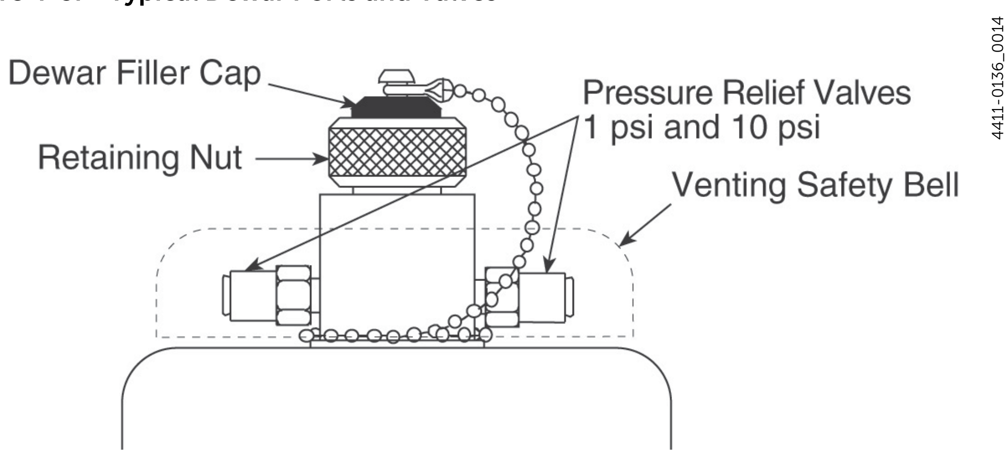
CAUTION!

Because of their low operating temperatures, cryogenically cooled cameras must always be connected to a camera that is powered on. If the camera power is turned off with liquid nitrogen remaining in the Dewar, the CCD will quickly become saturated with charge which cannot be readily removed without warming the camera to room temperature.

Perform the following procedure to safely fill the Dewar:

1. Loosen the retaining nut a few turns and then remove the LN Dewar port cap by pulling it straight out. See Figure 4-5.

Figure 4-5: Typical Dewar Ports and Valves



2. It is strongly recommended that an LN transfer Dewar with a pouring spout be used to transfer LN from the storage tank to the camera. When using a funnel, place a thin vent tube into the Dewar through the funnel to reduce splashing due to boiling LN.
3. Pour approximately 100 ml of LN into the Dewar. Stop for 5-10 minutes until a geyser-like vapor burst from the Dewar opening is observed. This burst is normal and has to do with reaching a thermal equilibrium between the LN and the Dewar container surfaces.

4. Fill up the Dewar (approximately 1.7 liters for the standard Dewar). To test the LN level, insert a straight piece of wire (a cryogenic dip stick) into the Dewar briefly and then remove it. The LN level will be indicated by the condensation on the wire.
5. Once the Dewar has been filled, replace the filler cap and hand-tighten the retaining nut by giving it approximately ¾ turn (or more) beyond the point where the nut feels snug.

WARNING!

Ice buildup may occur at the valve ports if the camera is being operated under high humidity conditions. If frost appears on the valves, periodically clean the outside of the valves so that ice does not prevent the valves from venting normally.

6. Set the desired temperature via the **Camera Temperature** dialog in WinSpec.

   To see when the array temperature reaches the target temperature and stabilizes, keep the Camera Temperature dialog open. When the target temperature has been reached, the dialog will report that the Current Temperature has **Locked**. An LN-cooled CCD normally reaches -100°C within 45-55 minutes.

CAUTION!

The pressure relief valves illustrated in Figure 4-5 under the protective covering will occasionally emit a plume of N_2 gas and mist.

Continuous hissing indicates that the vacuum in the Dewar jacket is probably inadequate. In this case, remove all LN from the Dewar and allow the Dewar to warm up to room temperature. Then contact Teledyne Princeton Instruments Customer Support for further instructions. Refer to Contact Information on page 130 for complete information.

NOTES:

1. Temperature regulation does not reach its ultimate stability for at least 30 minutes after temperature lock has been achieved. After this period of time the desired temperature is maintained with great precision.
2. The Camera Temperature dialog will not display temperature information while you are acquiring data.

4.7.1 Hold Times

Table 4-2 lists the approximate hold times for the standard side-on 1.7 liter Dewar at the lowest temperature setting.

Table 4-2: Typical CCD Array versus Dewar Hold Time

CCD Array	Dewar Hold Time
1340x100B	> 35 hours
1340x400B	> 30 hours

To maximize the hold time when leaving the camera overnight, in addition to topping off the Dewar, you will want to turn off the heater switch by setting the array temperature to its lowest operating temperature, typically -120° C, through software.

CAUTION!
Camera power must remain on.

This will bring the CCD to its minimum operating temperature and will minimize LN evaporation. The following day, set the temperature to the operating temperature via the **Detector Temperature** dialog in the WinX software.

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Chapter 5: Operation

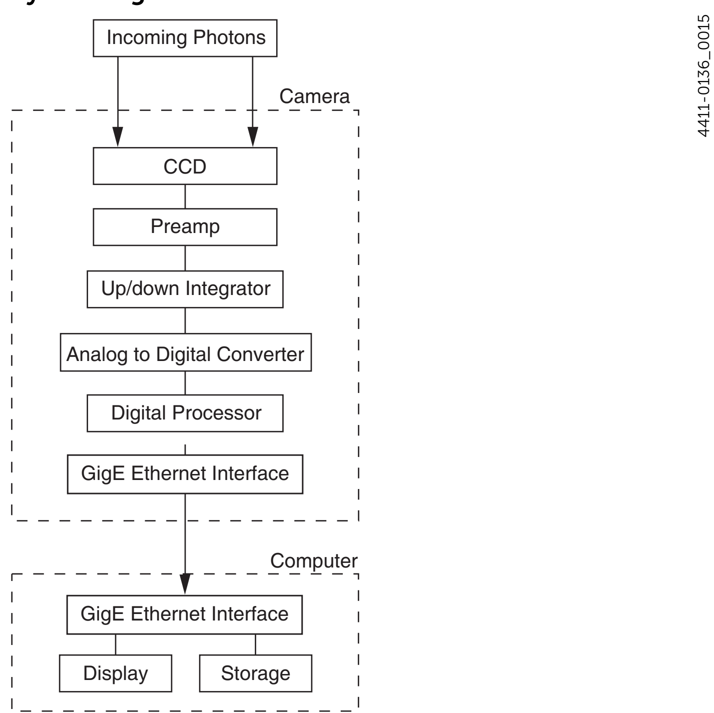
CAUTION!

With an LN-cooled camera, it is good practice to turn on the camera power and start at least one data collection while the camera is cooling down, and then to keep the camera powered on for the entire time the Dewar contains liquid nitrogen. This will establish and maintain the keep cleans mode of the camera so that, even when the CCD is not actively taking data, it will be continuously cleaning (i.e., shifting charge on the array to clear dark charge and cosmic ray artifacts.)

Once the PyLoN camera has been installed as described in prior chapters, operation of the camera is straightforward. For most applications you simply establish optimum performance using the **Focus** mode (WinX), set the target camera temperature, wait until the temperature has stabilized (refer to Section 5.3.3.1, CCD Temperature Control, on page 61,) 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 data is displayed and/or stored via the application software. This sequence is illustrated by the block diagram illustrated in Figure 5-1.

Figure 5-1: Block Diagram: System Light Path



Whether or not the data is displayed and/or stored depends on the data collection operation (**Focus** or **Acquire**) that has been selected in the application software. In WinX, these operations use the Experiment Setup parameters to establish the exposure time (the period when signal of interest is allowed to accumulate on the CCD). As might be inferred from the names, **Focus {Preview}** is more likely to be used in setting up the system (refer to Section 5.1, WinX First Light Instructions, on page 40 and/or Section 5.2, LightField First Light Instructions, on page 48,) 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.

The remainder of this chapter describes First Light procedures which include step-by-step instruction about 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, refer to Chapter 6, Advanced Topics, on page 75.

5.1 WinX First Light Instructions

CAUTION!

A PyLoN equipped with an internal shutter cannot be used with a spectrograph.

This section provides step-by-step instructions for placing your spectroscopy system in operation 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 of this section is that the PyLoN camera is to be operated with a spectrograph (e.g., a Teledyne Acton Research Series SP2300i,) on which it has been properly installed.

REFERENCES:

Refer to Appendix C, Spectrograph Adapters, on page 115 for complete information about mounting spectrograph adapters to the PyLoN.

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.

In a typical spectrograph, light enters the entrance slit and is collected by a collimating mirror. Collimated light strikes the grating and is dispersed into individual wavelengths (colors). Each wavelength leaves the grating at a different angle and is re-imaged by a focusing mirror onto the exit focal plane. Essentially, what a spectrograph does is to form an image of the entrance slit in the exit focal plane with each position in the plane representing a different wavelength. As each wavelength images at a different horizontal position, the spectrum of the input light is spread across the CCD. Individual wavelengths focused at different horizontal positions along the exit port of the spectrograph are detected simultaneously. Rotating the diffraction grating scans wavelengths across the CCD, allowing the intensity at individual wavelengths to be readily measured.

Information included in this section is based upon the following:

- The PyLoN system has been configured according to information included in:
  - Chapter 3, Installation Overview, on page 23;
  - Chapter 4, System Setup, on page 27;
  - Appendix C, Spectrograph Adapters, on page 115;
- Prior sections of this chapter have been read;
- Familiarity with the image application software;
- For LN-cooled applications, Section 4.7, Fill the Dewar, on page 35 has been reviewed;
- The PyLoN system is being operated in spectroscopy mode;
- The PyLoN camera is not equipped with an internal shutter;
- The spectrograph being used is equipped with an entrance slit shutter that is being controlled by the PyLoN camera via the Shutter connector.

Perform the following procedure to acquire First Light data using WinX:

1. Set the spectrograph entrance slit width to minimum (10µm if possible).
2. Power ON the camera (the switch is on the power supply).

   NOTE:

   The camera must be turned on before WinX is opened and WinX must be closed before the camera is turned off.

3. Mount a light source such as a Teledyne Princeton Instruments Hg and Ne/Ar Dual Switchable light source in front of the entrance slit.
4. Mount the camera to the spectrograph exit port.
5. Connect the shutter cable between the entrance slit shutter and the PyLoN 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 PyLoN **Shutter** connector to that connector.
6. Power ON the camera (i.e., switch the power supply ON) and fill the Dewar.
7. Turn on the computer power.
8. Launch the application software.

5.1.1 Configure 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.

Configure the following camera parameters:

- **Environment dialog (Setup ► Environment):** Check the DMA Buffer size. Large arrays (e.g., 2048 x 2048,) require a buffer size on the order of 32 MB. 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):** Because the Camera Detection wizard installed default values appropriate for your system, verify the settings on this page. To reload the defaults, you click on the **Load Defaults From Controller** button on this tab to load the default settings.
  - **Controller type:** This information is read from the camera.
  - **Camera type:** This information is read from the camera.
  - **Shutter type:** None or Large.
  - **Readout mode:** Full frame.
- **Detector Temperature (Setup ► Detector Temperature...):** -120°C

  The temperature should drop steadily. When the array temperature reaches the set temperature, there will be a **locked** indication at the computer monitor, 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 ±0.05°C.

NOTES:

1. 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.
2. The **Detector Temperature** dialog will not display temperature information while you are acquiring data.

- **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
  - **Full** loads the full size of the chip into the edit boxes.
  - **Store** will store the Pattern so it can be reused at another time.
- **Experiment Setup Timing tab (Acquisition ► Experiment Setup...):**
  - **Timing Mode:** Free Run
  - **Shutter Control:** Normal
  - **Safe Mode vs. Fast Mode:** Safe

5.1.2 Configure Spectrograph Parameters

Configure the following spectrograph parameters:

- **Define Spectrograph dialog (Spectrograph ► Define):**
  - Click on **Install/Remove Spectrograph**,;
  - Highlight the appropriate spectrograph name in the **Supported Spectrographs** list (e.g., **Teledyne Acton Research SP-300i** for a Teledyne Acton Research SP-2300i, or **Teledyne Acton Research SCT320** for an IsoPlane,);
  - Click on **Install Selected Spectrograph**.
- **Move Spectrograph dialog:**
  Choose the grating to be move, and then set it to:
  - 500 nm if using a Mercury lamp, or
  - 0.0 nm if using a Broadband source.

5.1.3 Verify Configuration

Perform the following procedure to verify WinX First Light configuration:

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. Proceed to Section 5.1.4, Rotational Alignment and Focusing, on page 44.
   - If there is no difference between the data displayed when the light source is on or off, perform the following procedure:
     a. Verify that the light source has power and is turned on.
     b. Verify that the entrance slit is open at least 10 μm.
     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 step a through step e have been performed, 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 proceed to Section 5.1.4, Rotational Alignment and Focusing, on page 44;
     - If the problem persists, stop data acquisition and proceed to step g.
   - If you do not hear a shutter operating and step a through step e have been performed, stop data acquisition and proceed to step g.

g. Verify the spectrograph has an entrance slit shutter.

h. 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 complete information.

i. If additional assistance is required, contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 130 for complete information.

5.1.4 Rotational Alignment and Focusing

The camera mounting hardware provides two degrees of freedom:

- Rotation;

  Rotation means the physical rotation of the camera while watching a live display on the monitor so that spectral lines will be perpendicular to the rows on the array.
- Focus.

  Focus means to physically move the camera back and forth through the focal plane of the spectrograph while watching a live display. The approach taken is to slowly move the camera in and out of focus and adjust for optimum focus.

5.1.4.1 Teledyne Acton Research Series Spectrograph

CAUTION!

A PyLoN camera equipped with an internal shutter cannot be used with a spectrograph.

Perform the following procedure to rotationally align and focus a Teledyne Acton Research SP-2300i spectrograph:

NOTE:

The following procedure can be easily adapted for other spectrographs.

Refer to Section 5.1.4.2, IsoPlane SCT-320 Spectrograph, on page 46 for information about rotationally aligning and focusing the IsoPlane SCT-320.

1. If you have not already done so, mount a light source such as a Teledyne Princeton Instruments Hg and Ne/Ar Dual Switchable light source in front of the entrance slit. 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 camera properly mounted to the spectrograph and powered on, make sure the spectrograph is properly connected to the computer, turn the spectrograph's power on, and wait for the spectrograph to initialize.
3. Verify that the spectrograph has been defined, choose the grating, and set the grating to 500 nm if using a mercury lamp or 0.0 nm if using a broadband source. Refer to Section 5.1.2, Configure Spectrograph Parameters, on page 43 for information about defining a spectrograph and moving the grating.

NOTE:

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 as the spectral line.

4. Verify that the slit is set to 10 μm. If necessary, adjust the **Exposure Time** to maintain optimum (near full-scale) signal intensity.
5. Wait until the camera temperature locks at its default temperature.
6. 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.
7. Adjust the rotational alignment. You do this by rotating the camera while watching a live display of the line (you may need to loosen two set screws 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 alignment and focus operations while watching a live image).

8. Next, 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).

   How focusing is accomplished is dependent upon the spectrograph:

   - Long focal-length spectrographs (e.g., Teledyne Acton Research SP-2300i)

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

5.1.4.2 IsoPlane SCT-320 Spectrograph

CAUTION!

A PyLoN camera equipped with an internal shutter cannot be used with a spectrograph.

Because the PyLoN is mounted directly to the mounting plate on the IsoPlane, the rotational alignment and focusing operations differ from how rotational alignment and focusing are performed for a Teledyne Acton Research Series spectrograph.

This procedure presumes familiarity with the locations of the mounting plate, Micrometer Compartment, and the locking set screw. If necessary, refer to the IsoPlane manual supplied with the spectrograph.

Perform the following procedure to rotationally align and focus an IsoPlane SCT-320 spectrograph:

1. Mount a Teledyne Princeton Instruments 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 PyLoN mounted to the spectrograph and connected to the computer, turn on the power and wait for the camera to initialize. If the camera is LN-cooled, the Dewar should be filled while the camera is ON.
4. Verify that the spectrograph has been defined, choose the grating, and set the grating to 500 nm if using a mercury lamp or 0.0 nm if using a broadband source. Refer to Section 5.1.2, Configure Spectrograph Parameters, on page 43 for information about defining a spectrograph and moving the grating.
5. Set the slit to 10 μm at a minimum. If necessary, adjust the **Exposure Time** to maintain optimum (near full-scale) signal intensity.
6. Wait until the camera temperature locks at its default temperature.
7. Turn on **Focus** mode.

8. Perform the following procedure to adjust the rotational alignment.
   a. Use a 9/64" hex wrench to loosen the four screws at the corners of the camera mounting plate.
   b. While watching a live display of the spectrum, select a peak to monitor and then rotate the camera (up to 4 degrees of rotation is possible.) The peak will go from broad to narrow and back to broad.
   c. Leave the camera rotation set for the narrowest achievable peak.

   Alternatively, acquire 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.
9. After completing the rotational alignment, re-tighten the four mounting plate screws.
10. Remove the cover from the Micrometer Compartment.
11. Using a 3/32" hex wrench, loosen the locking set screw.
12. While continuously acquiring data, adjust the micrometer until you maximize the intensity level of a selected peak or peaks.
13. Tighten down the locking set screw.
14. Place the Micrometer Cover on the spectrograph.
15. Replace and tighten all of the cover screws.
16. Halt data acquisition.

5.1.5 Data Acquisition

Perform the following procedure to acquire data:

1. After you have achieved focus, you can stop running in Focus mode.
2. Make any required changes to your experiment setup and software parameters. Changes might include adjusting the exposure time, setting up an entrance slit shutter, changing the timing mode to External Sync, or lowering the temperature.
3. Begin running **Acquire** mode. Data will be acquired and displayed/stored based on the experiment settings.
4. If you have completed data collection, you can leave the camera power on so the array temperature will remain locked or you can go to the shutdown instructions.

5.1.6 System Shutdown

Perform the following procedure to shut down the system in an orderly manner:

1. Before turning off the camera's power supply:
   a. Empty the Dewar (if the array is cooled by LN).
   b. Close WinX.
2. Turn off the camera power.

5.2 LightField First Light Instructions

CAUTION!
A PyLoN equipped with an internal shutter cannot be used with a spectrograph.

This section provides step-by-step instructions for operating a PyLoN in a spectroscopy configuration 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 of this procedure is that the PyLoN camera is to be operated with a spectrograph (e.g., Teledyne Acton Research Series 2300i spectrograph) on which it has been properly installed

REFERENCES:
Refer to Appendix C, Spectrograph Adapters, on page 115 for complete information about mounting spectrograph adapters to the PyLoN.

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.

- The PyLoN system has been configured according to information included in:
  - Chapter 3, Installation Overview, on page 23;
  - Chapter 4, System Setup, on page 27;
  - Appendix C, Spectrograph Adapters, on page 115;
- Prior sections of this chapter have been read;
- Familiarity with the image application software;
- For LN-cooled applications, Section 4.7, Fill the Dewar, on page 35 has been reviewed;
- The PyLoN system is being operated in spectroscopy mode;
- The PyLoN camera is not equipped with an internal shutter;
- The spectrograph being used is equipped with an entrance slit shutter that is being controlled by the PyLoN camera via the **Shutter** connector.

Perform the following procedure to acquire First Light data using LightField:

1. Set the spectrograph entrance slit width to minimum (10 µm if possible).
2. Power ON the spectrograph (i.e., switch the power supply ON).
3. Mount a light source such as a Teledyne Princeton Instruments Hg and Ne/Ar Dual Switchable light source in front of the entrance slit.
4. Mount the camera to the spectrograph exit port.
5. Connect the shutter cable between the entrance slit shutter and the PyLoN **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

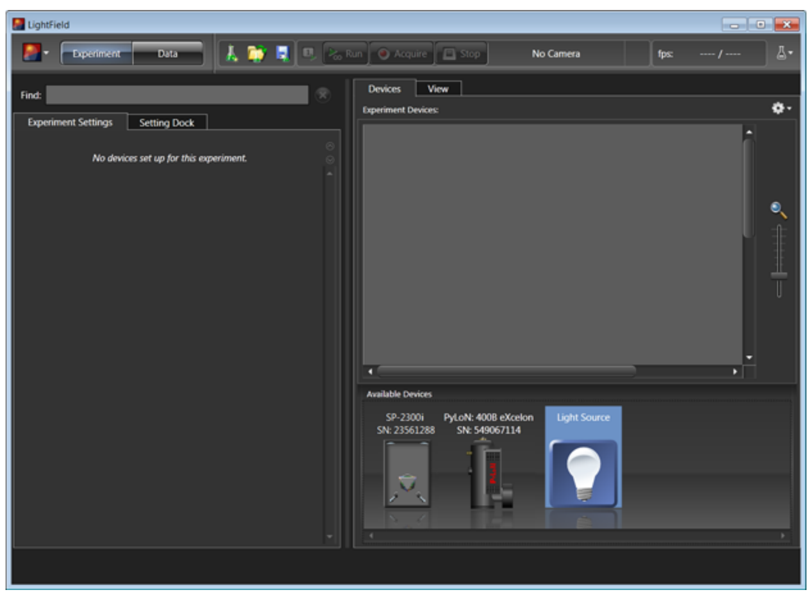
     A shutter mounted internally has an external shutter connector in the sidewall of the spectrograph. Connect a shutter cable from the PyLoN **Shutter** connector to that connector.
6. Power ON the camera (i.e., switch the power supply ON) and fill the Dewar.
7. Turn on the computer power.
8. Start the application software.

5.2.1 Configure System Parameters

Perform the following procedure to configure system parameters in LightField:

1. After LightField launches, you should see icons representing your camera and the spectrograph in the **Available Devices** area. For example, in Figure 5-2 the camera is a PyLoN:400B eXcelon® and the spectrograph is an SP-2356.

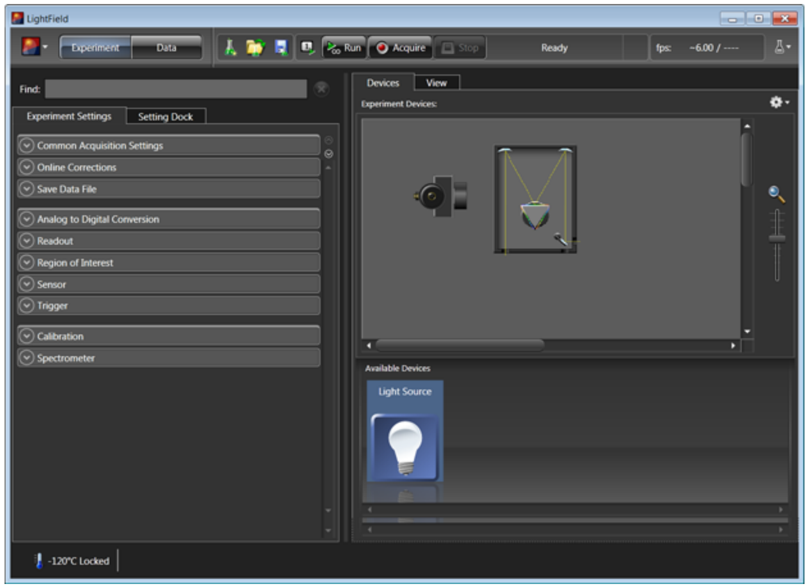
Figure 5-2: Typical Available Devices Area



4411-0136_0015

2. Drag the icons into the **Experiment Devices** area. See Figure 5-3.

Figure 5-3: Typical Experiment Devices Area



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NOTE:

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 which 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.

3. On the **Shutter** expander, select **Shutter Mode: Normal**.
4. Open the **Spectrometer** expander and 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.

5.2.2 Verify Configuration

Perform the following procedure to verify LightField First Light configuration:

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. Proceed to Section 5.2.3, Rotational Alignment and Focusing, on page 52.
   - If there is little or no difference between the data displayed when the light source is on or off:, perform the following procedure:
     a. Verify that the light source has power and is turned on.
     b. Verify that the entrance slit is open at least 10 μm.
     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 step a through step e have been performed, 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 proceed to Section 5.2.3, Rotational Alignment and Focusing, on page 52;
          — If the problem persists, stop data acquisition and proceed to step g.

          If you do not hear a shutter operating and step a through step e have been performed, stop data acquisition and proceed to step c.
     g. Verify 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 complete information.
     h. If additional assistance is required, contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 130 for complete information.

5.2.3 Rotational Alignment and Focusing

The camera mounting hardware provides two degrees of freedom:

- Rotation;
  Rotation means the physical rotation of the camera while watching a live display on the monitor so that spectral lines will be perpendicular to the rows on the array.
- Focus.
  Focus means to physically move the camera back and forth through the focal plane of the spectrograph while watching a live display. The approach taken is to slowly move the camera in and out of focus and adjust for optimum focus.

5.2.3.1 Teledyne Acton Research Series Spectrograph

CAUTION!

A PyLoN camera equipped with an internal shutter cannot be used with a spectrograph.

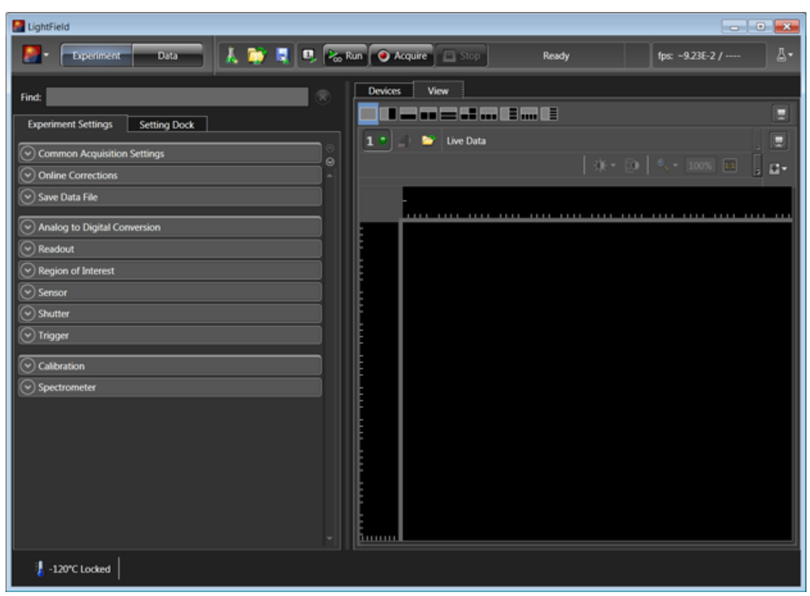
Perform the following procedure to rotationally align and focus a Teledyne Acton Research SP-2300i spectrograph:

NOTES:

1. This procedure can be adapted for other spectrographs.
   Refer to Section 5.2.3.2, IsoPlane SCT-320 Spectrograph, on page 56 for information about rotationally aligning and focusing the IsoPlane SCT-320.
2. This procedure presumes that the PyLoN camera and spectrograph are powered on and their respective icons have been moved into the Experiment Devices area as illustrated in Figure 5-3.

1. Click on the **View** tab, just above **Experiment Devices**, to change to the display area. See Figure 5-4.

Figure 5-4: Typical LightField View Area



4411-0136_0017

2. If you have not already done so, mount a light source such as a Teledyne Princeton Instruments Hg and Ne/Ar Dual Switchable light source in front of the entrance slit. 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 435.8 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

NOTE:

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 435.833 as the spectral line.

4. Set the slit to 10 μm. If necessary, adjust the **Exposure Time** to maintain optimum (i.e., near full-scale,) signal intensity.
5. Wait until the camera 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 creates three 1-row high ROIs and begins data acquisition:
   - One ROI is near the top of the array;
   - One ROI is near the middle of the array;
   - One ROI is near the bottom of the array.

   Data will be continuously acquired and displayed but will not be stored.
8. Adjust the rotational alignment by rotating the camera while watching a live display of the line.

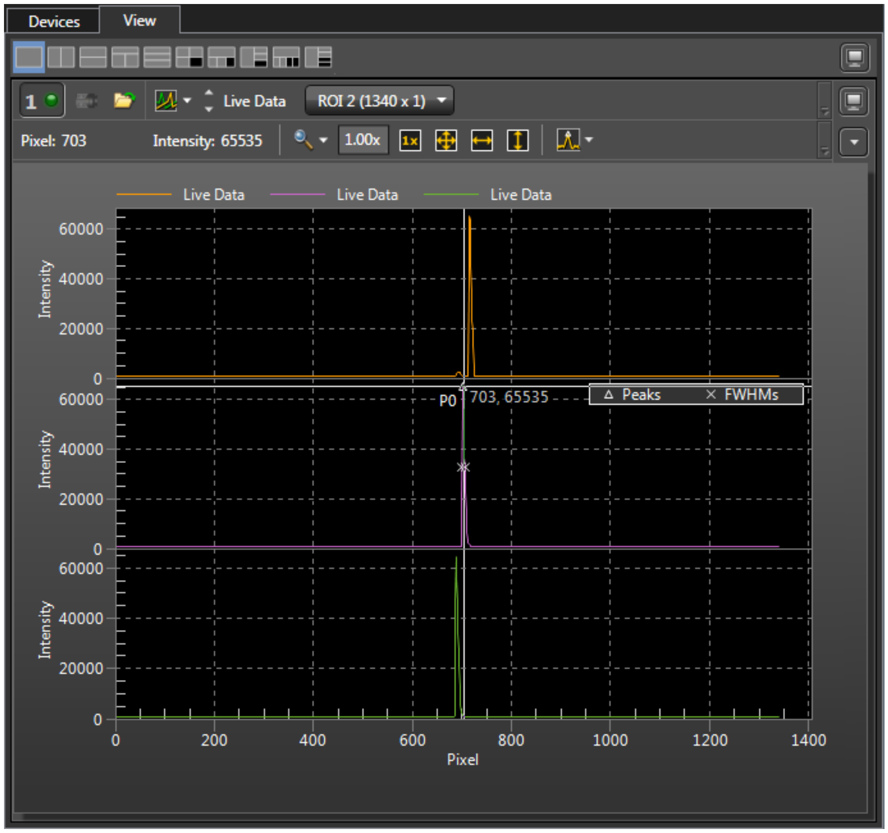
NOTE:

The two set screws securing the spectrograph adapter may need to be loosened.

Click on the peak to monitor during the rotational alignment. This positions the large cursor to provide a vertical reference line across all of the ROIs. Rotate the camera until the selected peak is aligned horizontally within all of the ROIs.

See Figure 5-5.

Figure 5-5: Spectrometer Alignment: Before Rotational Alignment (Typical)



4411-0136_0018

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.

See Figure 5-6.

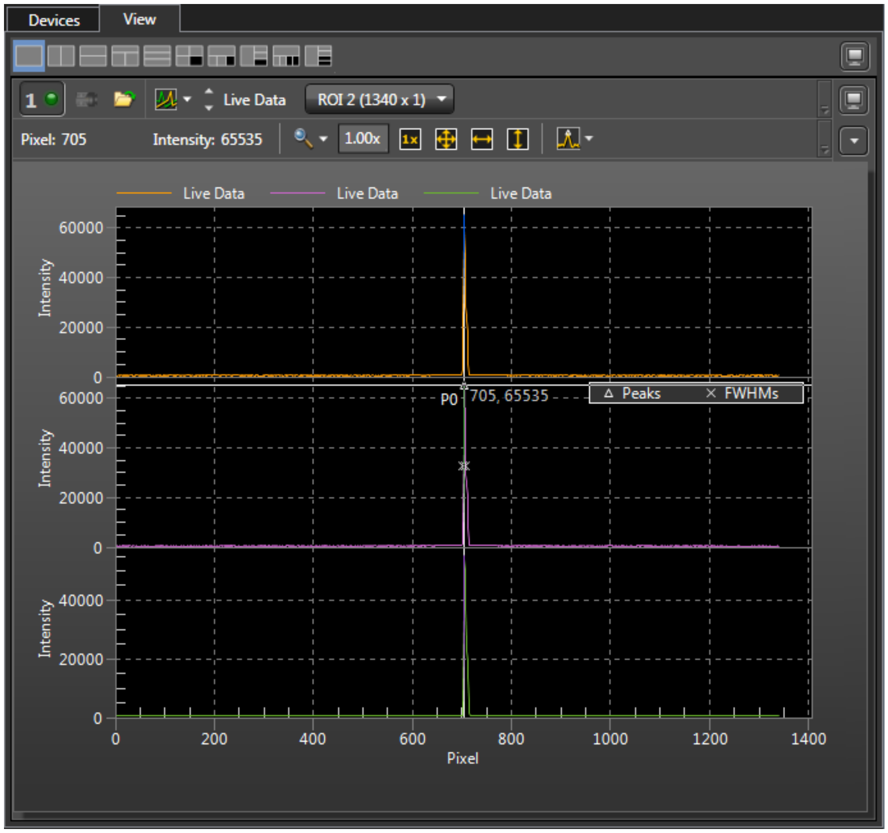
NOTE:

When aligning accessories (e.g., fibers, lenses, optical fiber adapters, etc.,) align the spectrograph to the slit first.

Next, align the accessory without disturbing the camera position.

The procedure is identical to that used to focus the spectrograph (i.e., perform focus and alignment operations while watching a live image).

Figure 5-6: Spectrometer Alignment: After Rotational Alignment (Typical)



4411-0136_0019

9. 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 is dependent upon the spectrograph:

   - Long focal-length spectrographs (e.g., Teledyne Acton Research SP-2300i)

     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.

10. Tighten the spectrograph set screws to secure the spectrograph adapter.
11. Halt data acquisition.

5.2.3.2 IsoPlane SCT-320 Spectrograph

> ⚠ **CAUTION!**
> A PyLoN equipped with an internal shutter cannot be used with a spectrograph.

Because the PyLoN is mounted directly to the mounting plate on the IsoPlane, the rotational alignment and focusing operations differ from how rotational alignment and focusing are performed for a Teledyne Acton Research Series spectrograph.

This procedure presumes familiarity with the locations of the mounting plate, Micrometer Compartment, and the locking set screw. If necessary, refer to the IsoPlane manual supplied with the spectrograph.

Perform the following procedure to rotationally align and focus an IsoPlane SCT-320 spectrograph:

1. Mount a light source such as a Teledyne Princeton Instruments Hg and Ne/Ar Dual Switchable light source in front of the entrance slit.
2. With the IsoPlane properly connected to the computer, turn the power on, wait for the spectrograph to initialize.
3. With the PyLoN mounted to the spectrograph and connected to the computer, turn on the power and wait for the camera to initialize. The Dewar should be filled.
4. Start the application software. Because you are using LightField, you will need to drag the icons for the PyLoN 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. Wait until the camera locks at its default temperature.
7. Loosen the four screws at the corners of the camera mounting plate.
8. Select the **Align Spectrometer** function from the **Experiment** menu to open the **Spectrometer Alignment** dialog.

   This dialog describes the changes that LightField will make to the current setup to assist you in performing rotational alignment of the array to the spectrograph's optics. When you click on the **Begin** button, the modifications are made and continuous live data will be displayed as you rotate the camera.
9. Click on the peak you will be monitoring for the alignment. This will display the data cursor, which you can position at the top of the peak. Since the data cursor spans the ROIs, you can use the data cursor as your vertical reference.
10. Slowly rotate the camera until the peaks align in all of the ROIs.

    Alternatively, you can acquire an image, display the large data cursor, 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.
11. After completing the rotational alignment, click on the Stop button.
12. Re-tighten the four mounting plate screws.
13. Next, remove the cover from the Micrometer Compartment.
14. Using a 3/32” hex wrench, loosen the locking set screw.
15. Click on **Run**, and while continuously acquiring data, adjust the micrometer until you maximize the intensity level and minimize the FWHM of a selected peak or peaks. You may want to use the **Peak Find** function to identify peaks and display FWHM widths.

16. Tighten down the locking set screw.
17. Place the Micrometer Cover on the spectrograph.
18. Replace and tighten all of the cover screws.
19. Halt acquisition.

5.2.4 Data Acquisition

Perform the following procedure to acquire data:

1. After you have achieved focus, you can stop running in **Alignment** mode.
2. Make any required changes to your experiment setup and software parameters. Changes might include adjusting the exposure time, setting up an entrance slit shutter, changing the timing mode to External Sync, or lowering the temperature.
3. Begin running **Acquire** mode. Data will be acquired and displayed/stored based on the experiment settings.
4. If you have completed data collection, you can leave the camera power on so the array temperature will remain locked or you can go to the shutdown instructions.

5.2.5 System Shutdown

Perform the following procedure to shut down the system in an orderly manner:

1. Before turning off the camera's power supply:
   a. Empty the Dewar (if the array is cooled by LN).
   b. Close LightField.
2. Turn off the camera power.

5.3 Exposure and Signal

This section provides information about factors that can affect the signal acquired on the CCD array, including:

- CCD Array Architecture;
- Exposure Time;
- Cooling the CCD;
- Dark Charge;
- Saturation

5.3.1 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.

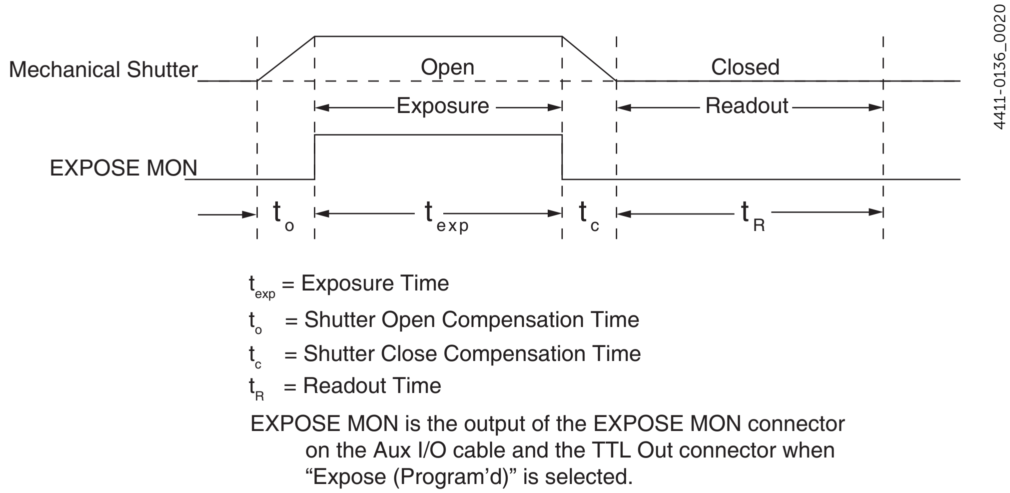
CCD arrays perform three essential functions: photons are transduced to electrons, integrated and stored, and finally read out. CCDs are very compact and rugged and can withstand direct exposure to relatively high light levels, magnetic fields, and RF radiation. They are easily cooled and can be precisely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

5.3.2 Exposure Time

Exposure, which is set on the **Experiment Setup** ► **Main tab** {**Common Acquisition Settings** expander}, is the time between start 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 read out. 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 read out and cleaning starts again.

Figure 5-7 illustrates how the exposure period is measured. The output of the **EXPOSE MON BNC** (one of the BNC connectors on the **AUX I/O** cable) can be used to monitor the exposure and readout cycle (t_R). This signal is also shown in Figure 5-7. The value of t_c is shutter type dependent. Because PyLoN cameras do not usually have an internal shutter, the t_c is very small. **EXPOSE MON** is low during readout, high during exposure, and high during shutter compensation time.

Figure 5-7: Timing Diagram: Mechanical Shutter Action with EXPOSE MON Output



5.3.2.1 Continuous Exposure

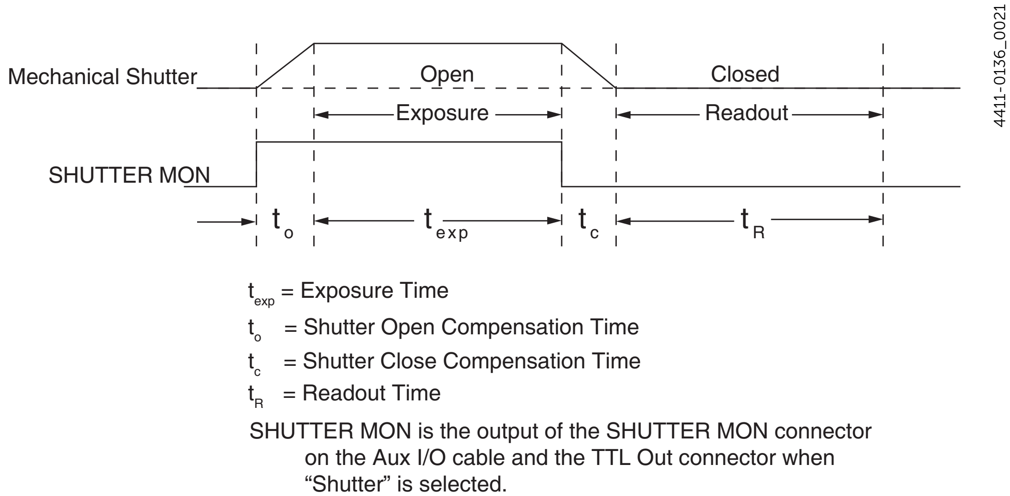
Because spectroscopy CCDs typically have their parallel shifting aligned vertically (perpendicular to the spectrum), smearing (caused by light falling on the array while the charge from the acquired spectra is shifted toward the readout register) does not affect the spectral resolution, only the intensity 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 or with shutter control set to disabled open with very little loss of performance.

5.3.2.2 Exposure with Shutter

If the CCD is set up for imaging mode (in WinSpec, the 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. With an LN-cooled camera containing the optional internal shutter, you can use that shutter to block the light: this shutter is synchronized to the exposure-readout cycle and has a shutter open (t_O) and closed compensation time (t_C) of approximately 28 ms. With a standard PyLoN camera (i.e., shipped without an internal shutter,) you need to use other ways to prevent light from falling on the array during readout.

When a camera does not have an internal shutter, you need to control the light source or use an external shutter to block light from the array during readout. If the light source can be controlled electronically via the output of the **SHUTTER MON** BNC, the CCD can be read out in darkness. Another way to prevent light from falling on the array during readout is to use a Teledyne Princeton Instruments-supplied 25 mm external shutter, typically used at a spectrograph entrance slit. This shutter can then be controlled by the camera and would be synchronized to the exposure-readout cycle as shown in Figure 5-8. The shutter compensation time (t_C) is approximately 8 ms for the 25 mm shutter.

Figure 5-8: Timing Diagram: Mechanical Shutter Action with SHUTTER MON Output



5.3.3 Cooling the CCD

As stated previously, the PyLoN family of cameras is cryogenically-cooled. With cryogenic cooling, the array can be operated at temperatures in the range of -70°C to -120°C. Refer to Table 5-1. Generally speaking, the lower the array temperature, the lower the dark current and, therefore, the greater the sensitivity.

Table 5-1: Approximate Temperature Range versus Camera Model

Camera Model	Temperature Range (approximate)
PyLoN: 100B (1340x100)	-70°C to -120°C
PyLoN: 400B (1340x400)	-70°C to -120°C

Cryogenically-cooled cameras use liquid nitrogen (LN2) to reduce the temperature of the CCD. The liquid nitrogen is stored in a Dewar that is enclosed in a vacuum jacket for minimal external thermal losses. The chip temperature is regulated by a heating element driven by closed-loop proportional control circuitry. A thermal sensing diode attached to the cooling block of the camera monitors the chip temperature.

CAUTION!

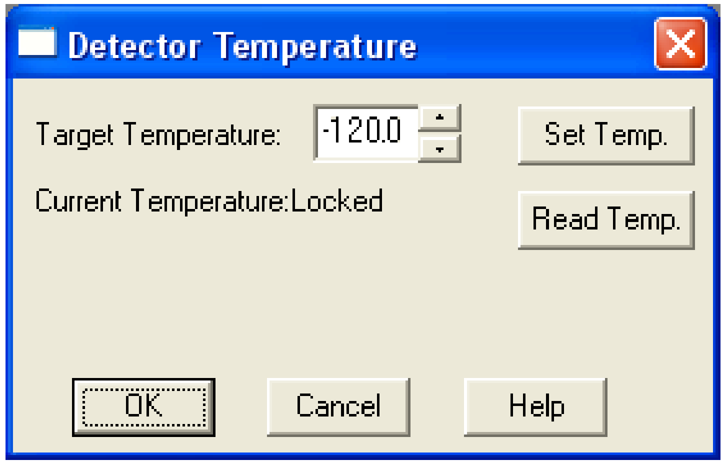
Cryogenically-cooled cameras, because of their low operating temperatures, must always be connected to a powered ON camera. If the camera power is turned off with liquid nitrogen remaining in the Dewar, the CCD will quickly become saturated with charge, which cannot be readily removed without warming the camera to room temperature.

5.3.3.1 CCD Temperature Control

Lowering the temperature of the CCD will generally enhance the quality of the acquired signal.

- When using WinX, temperature control is configured on the **Setup ► Detector Temperature** dialog. See Figure 5-9.

Figure 5-9: Typical WinSpec/32 Detector Temperature Dialog



- When Light Field is being used, temperature control is configured on the **Sensor** expander.

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

The deepest operating temperature for a system depends on the CCD array size and the CCD packaging. 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. Refer to Table 5-1, Approximate Temperature Range versus Camera Model, on page 60 for information about the typical range of cooling temperatures. Once lock occurs, it is okay to begin focusing. However, you should wait an additional thirty minutes before taking quantitative data so that the system has time to achieve optimum thermal stability.

NOTE:

The Detector Temperature dialog will not display temperature information while acquiring data.

5.3.4 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. 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, the camera should operated at the lowest CCD temperature possible. Refer to Section 5.3.3, Cooling the CCD, on page 60.

CAUTION!

If a sudden change in the baseline signal is observed, there may be excessive humidity in the vacuum enclosure of the camera.

Immediately turn off the camera power, remove the liquid nitrogen, and contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 130 for complete information.

NOTE:

Do not be concerned about either the DC level of this background or its shape unless it is very high (i.e., >1000 counts for LN- cooled.) This is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. 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.

5.3.5 Saturation

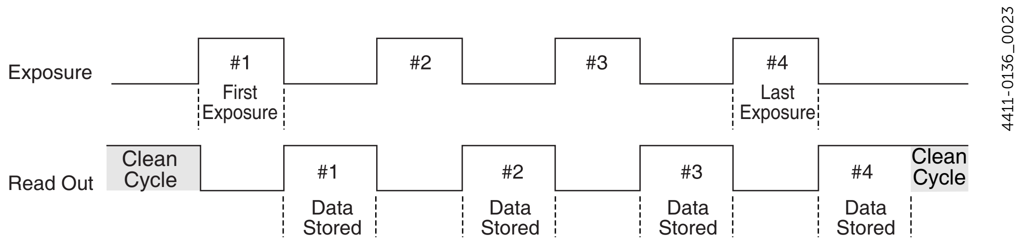
When signal levels in some part of the image are very high, charge generated in one pixel may exceed the well capacity of the pixel, spilling over into adjacent pixels in a process called blooming. In this case a more frequent readout is advisable, with signal averaging to enhance S/N (Signal-to-Noise 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 signal to noise (S/N) ratio approximately linearly with the length of exposure time. There is, however, a maximum time limit for on-chip averaging, determined by either the saturation of the CCD pixels by the signal or the loss of dynamic range due to the buildup of dark charge in the pixels.

5.3.6 Cleaning

The basic cleaning function is implemented by clean cycles. These cycles start when you turn the camera on and a clean pattern is programmed into the camera. Their purpose is to remove charge that accumulates on the array while the camera not acquiring data (i.e., exposing and reading out the array.) Figure 5-10 illustrates the timing diagram for an experiment configured to acquire four (4) images in Freerun {No Response} timing mode. In this diagram clean cycles occur before the first exposure and after the last readout period.

Figure 5-10: Timing Diagram: Clean Cycles



NOTE:

The start of the exposure is signaled by SCAN going high but will not occur until the current clean cycle has finished.

The configuration of clean cycles is performed on the **Hardware Setup ► Cleans/Skips** tab {via the **Sensor Cleaning** pane accessed on the **Sensor** expander}. When you set up the camera for the first time, default values are automatically inserted into these fields. These will give the best results for most applications. Even so it is a good idea to know what these entries mean with regard to cleaning.

- **Number of Cleans {Number of Clean Cycles}**
  Typically set to one (1). These are additional clean cycles that can be required after a start exposure signal is received and the current clean cycle has finished. The maximum value for this entry depends on the camera.
- **Number of Strips per Clean {Clean Cycle Height}**
  Sets the number of rows that will be shifted and discarded per clean cycle. While a large number such as the number of rows in the array may result in the best cleaning of the array, the trade off is that there may be a significant delay between the receipt of a start exposure signal and the beginning of the actual exposure. This delay occurs because the current clean cycle must be completed before a start exposure signal received during the cycle will be implemented. Typically, the default setting is much smaller and in time critical experiments, the setting should be 1 or 2.
- **Continuous Cleans {Clean Until Trigger}**
  Available when the start of exposure is tied to an external trigger.
  - In WinX, this cleaning becomes active when **External Sync** timing mode is selected.
  - In LightField, it becomes active when **Trigger Response** is set to **Readout Per Trigger** or **Shift Per Trigger**.

    See Figure 6-5 on page 78 for a timing diagram that illustrates LightField's **Clean Until Trigger** timing.

- **Skip Serial Register Clean** (deselected) {**Clean Serial Register**}

  The Top margin inactive parallel strips on a CCD are made up of the dark pixels that come before the active strips on a sensor as they exit to the serial register. When these are available (i.e., **Pre Dummies** {**Top Margin**} > 0,) they serve the purpose of cleaning the serial register before readout of the active strips.

  In LightField, if there are no inactive parallel strips (i.e., **Top Margin** = 0,) selecting **Clean Serial Register** forces a clean of the serial register before readout of the active strips.
- **Cleaning and Skipping**

  These parameters are used by the **Cleaning and Skipping** algorithm which decomposes a sensor segment to be cleared into sections of unequal size and then bins and reads out each section so that the largest section is read out first and the last sections read out are small enough to avoid blooming, thus leaving no charge on the sensor when the next exposure begins. The default values vary from camera to camera depending on sensor size and serial register capacity. The default values of these parameters will generally give good results.
  - **Final Section Height**

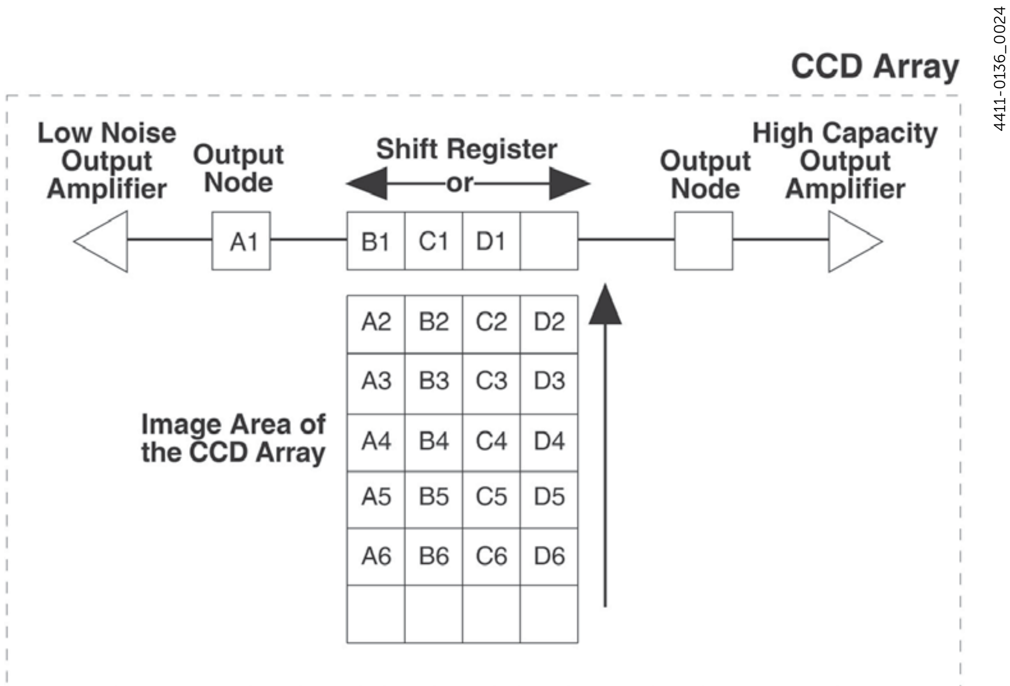
    Determines the number of rows contained in the final section(s) of cleaning.
  - **Final Section Count**

    Determines how many rows are binned into the smallest of the sections used to read out and discard charge from the sensor during cleaning and while reading out ROIs smaller than full sensor.

5.4 Readout

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. See Figure 5-11.

Figure 5-11: Array Terms for a CCD with Dual Readout Ports



WinSpec and LightField allow you to specify the type of readout (full frame or binned), the **Readout Port** {**Quality**}, and the **Gain** (the number of electrons required to generate an ADU).

5.4.1 Full Frame Readout

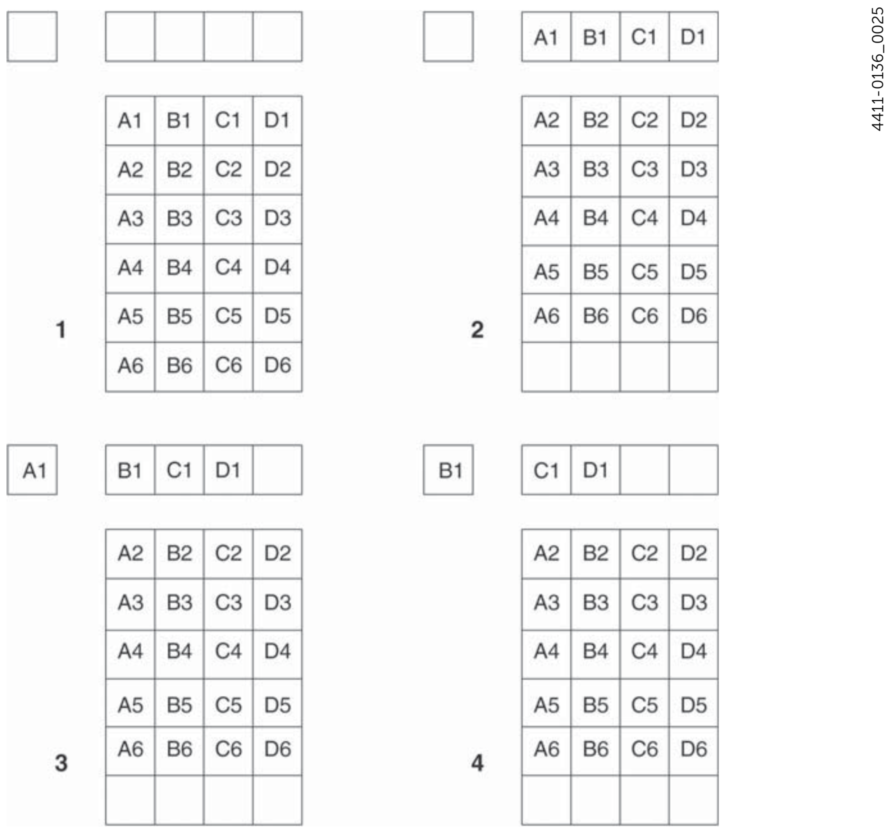
This section uses a simple 6 x 4 CCD to explain readout at full resolution, where every pixel is digitized separately.

The upper left drawing illustrated in Figure 5-12 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.

NOTE:

PyLoN cameras provide the choice of amplifier (i.e., 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, Figure 5-12 illustrates the readout to the left.

Figure 5-12: Full Frame at Full Resolution



Readout of the CCD begins with the simultaneous shifting of all pixels one row toward the shift register, in this case the row at top. The shift register is a single line of pixels along one 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. The equations that determine the rate at which the CCD is read out are provided in the following sections.

Acquisition Time

The time required to acquire a full frame at full resolution is:

(1)
$$t_{acq} = t_o + t_R + t_{exp} + t_c$$

where:

- t_o is the shutter open compensation time;
- t_{exp} is the exposure time;
- t_c is the shutter close compensation time;
- t_R is the CCD readout time.

Readout Time

The readout time is approximated by:

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

where:

- t_R is the CCD readout time;
- 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.

5.4.2 Binning

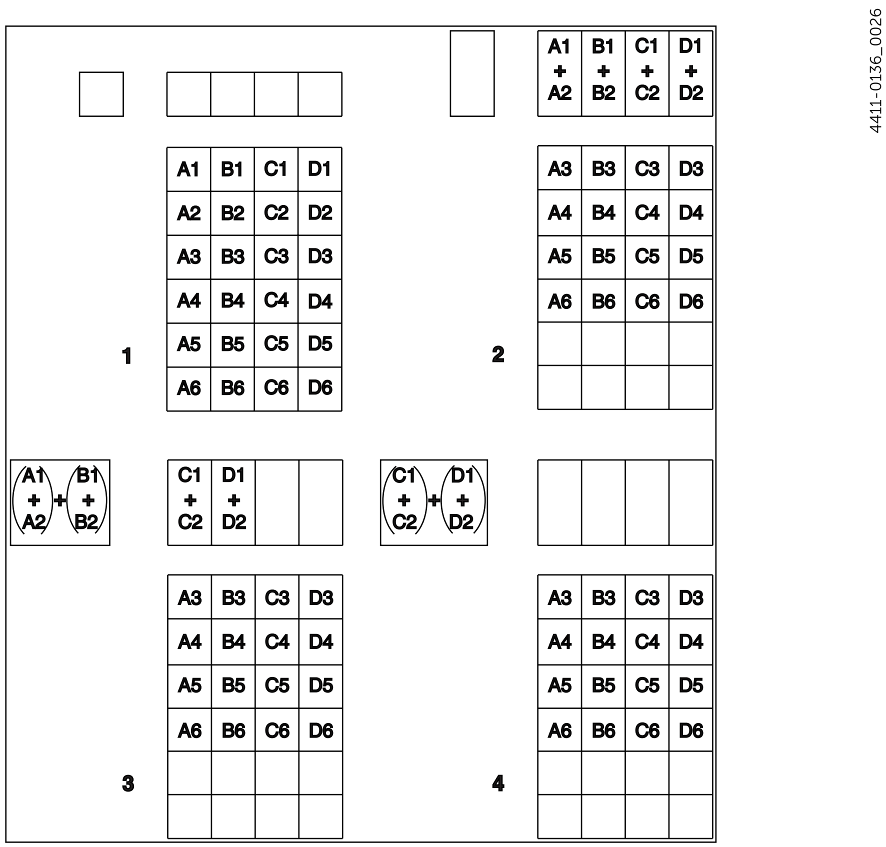
Binning is the process of adding the data from adjacent pixels together to form a single pixel (sometimes called a super-pixel), and it can be accomplished in either hardware or software. Rectangular groups of pixels of any size may be binned together, subject to some hardware and software limitations.

5.4.2.1 Hardware Binning

Hardware binning is performed *before* the signal is read out by the preamplifier. 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.

Figure 5-13 illustrates an example of 2 × 2 binning. Each pixel of the image displayed by the software represents four pixels of the CCD array. Rectangular bins of any size are possible.

Figure 5-13: 2 x 2 Binning for Images



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 x n binning is approximated using a more general version of the full resolution equation, Equation 2 on page 67.

The modified equation is:

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

5.4.2.2 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 lost.

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.

5.4.3 Readout Port {Quality} Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Many PyLoN systems are available with dual readout ports and amplifiers (one set at each end of the shift register as illustrated in Figure 5-11. If your system has dual readout ports, you can choose the **Readout Port** {**Quality**} 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.

5.4.4 Controller Gain {Analog 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}.

Valid options are:

- 1 {Low};

  Users who measure high-level signals may wish to select Low to allow digitization of larger signals.
- 2 {Medium};

  Medium is suitable for experiments within the mid-level intensity range.
- 3 {High}.

  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 included with each camera provides the measured gain values at all settings.

Table 5-2 lists some sample Controller gain values.

Table 5-2: Example of Controller Gain {Analog Gain} versus Readout Port

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

For 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 values at the 1, 2, and 3 settings depend upon the CCD installed.

- 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.

5.5 Digitization

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. Refer to Section 5.4, Readout, on page 65 for additional information.

Factors associated with digitization include the digitization rate and baseline signal. Depending on the camera model, you may be able change the speed at which digitization occurs and/or offset the baseline. These factors are discussed in the following paragraphs.

5.5.1 Digitization Rate {Speed}

The PyLoN camera has a seven-speed digitizer, which enables software-selectable rates of:

- 50 kHz;
- 100 kHz;
- 200 kHz;
- 500 kHz;
- 1 MHz;
- 2 MHz;
- 3 MHz, 4 MHz, or 5 MHz (CCD-specific)

Multiple digitization provides optimum signal-to-noise ratios at all readout speeds but 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 faster the selected conversion speed, the faster the data collection and the higher the noise level. If noise performance is the paramount concern, selecting a slower conversion speed will typically reduce the noise level and enhance the signal-to-noise ratio. Switching between the conversion speeds is completely under software control for total experiment automation.

NOTE:

In WinX, the ADC rate is configured on the **Experiment Setup** ► **ADC** tab.

In LightField, the speed is configured on the **Analog-Digital Conversion** expander.

5.5.2 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 pattern will appear. This pattern can be dealt with by using background subtraction. With background subtraction, a background image is acquired while light is blocked from entering the camera and is then subtracted from a subsequently acquired illuminated image.

CAUTION!

If a sudden change in the baseline signal is observed, there may be excessive humidity in the vacuum enclosure of the camera.

Immediately turn off the camera power, remove the liquid nitrogen, and contact Teledyne Princeton Instruments Customer Support. Refer to Contact Information on page 130 for complete information.

NOTE:

Do not be concerned about either the DC level of this background or its shape unless it is very high (i.e., >1000 counts for LN- cooled.) This is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. 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.

5.6 Dark Current

Exposing the CCD to bright light (10x saturation) when cold (<-70°C) will cause the dark current in the exposed pixels to be 3 to 10 times higher than normal for that operating temperature. This effect is due to the formation of temporary traps. The effect can be reversed by allowing the camera to warm up to room temperature.

5.7 High Humidity

In high humidity climates it is not unusual to require continuous flushing of the spectrometer’s exit port with nitrogen to prevent condensation on the window. If condensation occurs, it will obscure the light and degrade the data. High humidity can also result in ice buildup at the Dewar valve ports. Any frost that appears on the valves should be periodically cleaned off to ensure unblocked venting of LN from the Dewar.

5.8 Shutter

WARNING!

Halt data acquisition before connecting or disconnecting the shutter cable. Disconnecting or connecting the shutter cable to the camera while the camera is running in Focus {Preview/Run} mode or Acquire mode can destroy the shutter or the shutter drive circuitry.

An optional 1.59" (40 mm) internal shutter is available for LN-cooled cameras. This shutter has a 28 ms open time and a 28 ms close time. Contact the factory for up-to-date information about available shutters. Refer to Contact Information on page 130 for complete information.

Chapter 6: Advanced Topics

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization. Synchronization is configured on the **Experiment Setup** ► **Timing** tab in WinX and on the **Trigger** and **Shutter** expanders in LightField.

The following sections/topics are included in this chapter:

6.1 Timing Modes

The basic PyLoN Timing Modes {Trigger Response} for Full Frame operations are:

- Free Run {No Response};
- External Sync {Readout Per Trigger};
- Bulb Trigger {Expose During Trigger Pulse} Timing.

These modes are combined with the Shutter Control {Shutter Mode} options to provide the widest variety of modes for precision experiment synchronization.

The shutter options available for Full Frame operation are:

- Normal;
- Disabled Opened;
- Disabled Closed.

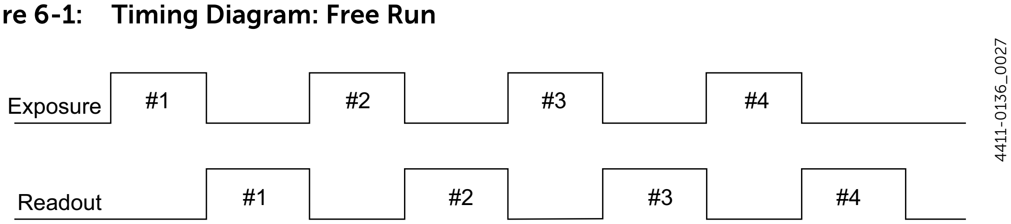
Disabled simply means that the shutter will not operate during the experiment. Disabled closed is useful for making dark charge measurements. PreOpen {Open Before Trigger}, available in the External Sync {Readout Per Trigger} and External Sync with Continuous Cleans {Clean Until Trigger} modes, opens the shutter as soon as the PyLoN is ready to receive an External Sync pulse at the Trigger In connector. 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 {No Response}, where the modes of shutter operation are identical, both Normal and PreOpen {Open Before Trigger} lines are shown in the timing diagrams and flow chart.

6.1.1 Free Run {No Response}

In this mode, there is no external triggering, or the camera is ignoring external triggers and all settings are read from the setup parameters, making the duration of each exposure time constant and the interval times between exposures constant. See Figure 6-1.

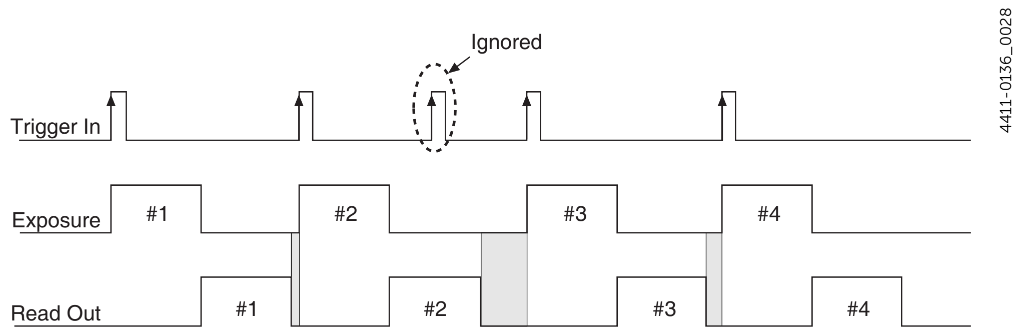
Figure 6-1: Timing Diagram: Free Run



6.1.2 External Sync {Readout Per Trigger}

In this mode, each frame in a sequence requires a trigger. Each frame is exposed for the length of time entered into the software and is then read out. If a trigger arrives during the exposure-readout of the previous frame, it is ignored. See Figure 6-2. For a sequence of one frame, bulb mode and trigger-first mode are the same. The shaded areas denote the idle time between exposures.

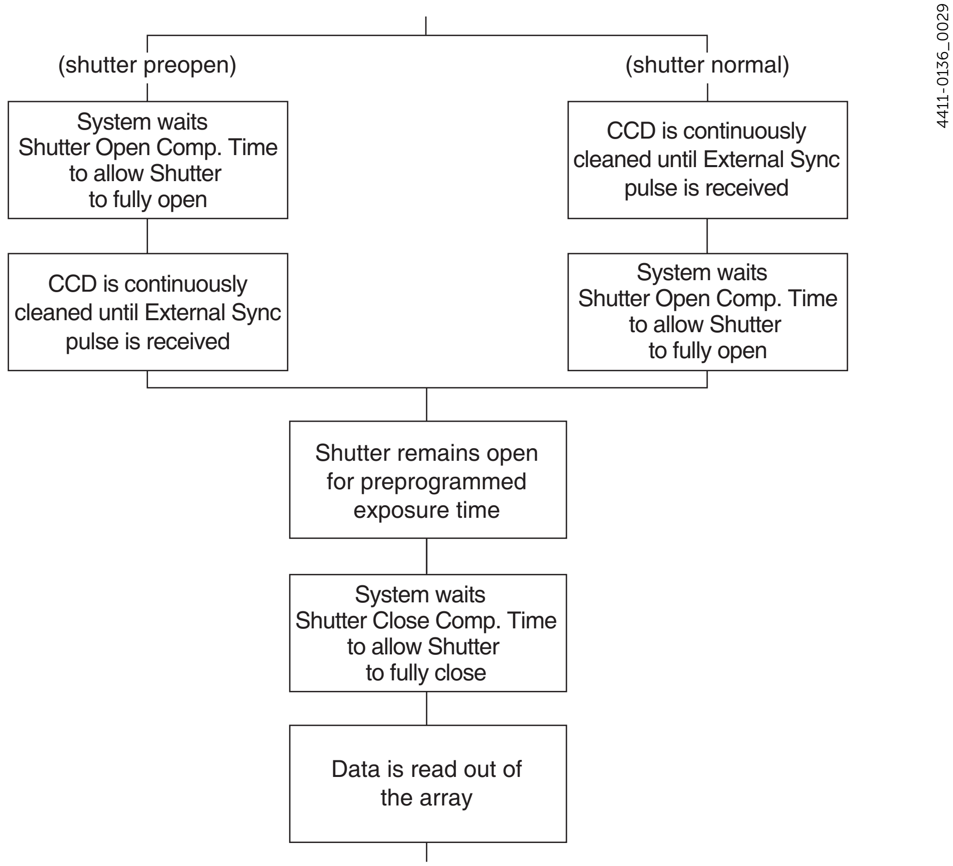
Figure 6-2: Timing Diagram: External Sync



6.1.3 External Sync with Continuous Cleans {Clean Until Trigger} Timing

Another timing mode available with the PyLoN is Continuous Cleans {Clean Until Trigger}. In addition to the standard cleaning of the array, which occurs after the camera is enabled, this mode removes any charge from the array until the moment the External Sync pulse is received. See Figure 6-3.

Figure 6-3: Flowchart: Continuous Cleans {Clean Until Trigger}



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 {Normal} shutter operation, the shutter is opened for the set exposure time. With PreOpen {Open Before Trigger} shutter 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 µsec 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.

Figure 6-4 illustrates the timing diagram for Continuous Cleans in WinX, while Figure 6-5 is the timing diagram for Clean Until Trigger in LightField.

Figure 6-4: Timing Diagram: WinX Continuous Cleans

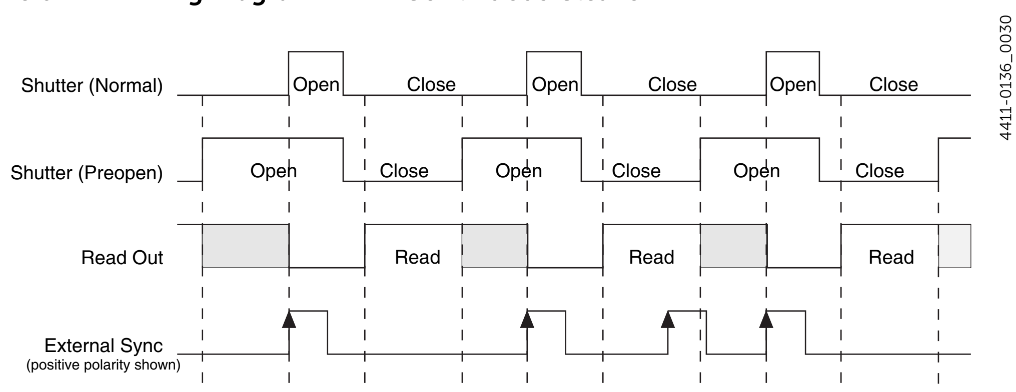
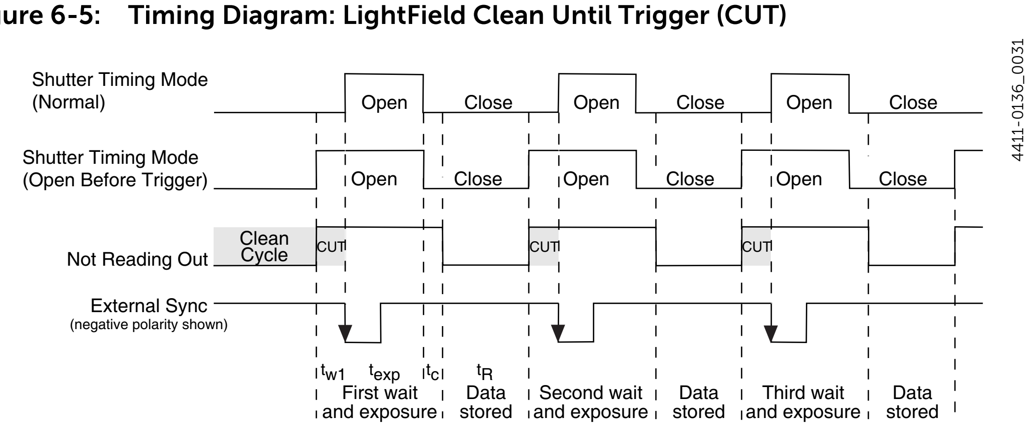


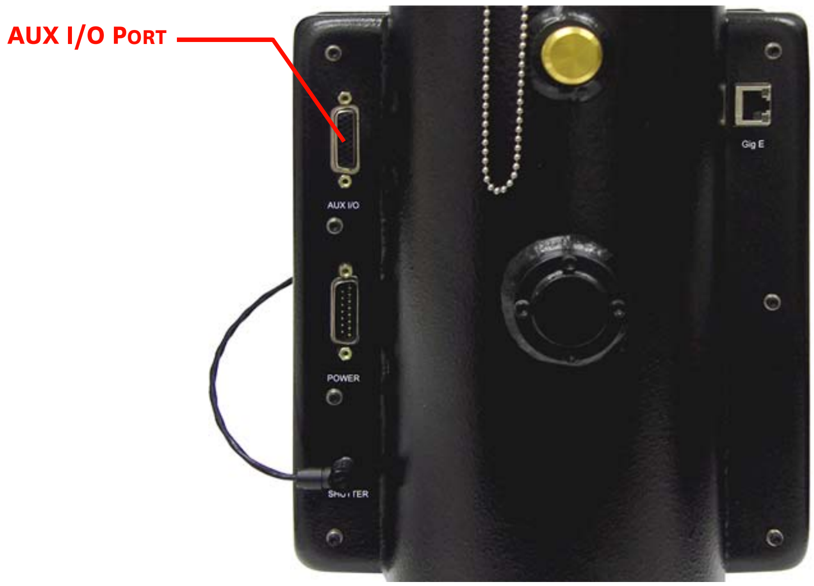
Figure 6-5: Timing Diagram: LightField Clean Until Trigger (CUT)



6.1.3.1 Trigger Input

The selected Timing Mode {Trigger Response} determines how the camera will respond to an External Sync pulse that is input at the **TRIGGER IN** connector of the **AUX I/O** cable connected to the rear of the camera. See Figure 6-6.

Figure 6-6: Rear Panel of PyLoN Camera



Things to keep in mind when configuring the External Sync pulse input include:

- Pulse Height
  0 to +3.3 V_{DC} logic levels (TTL-compatible).

  Pulse Width (trigger edge frequency)
  The time between trigger edges.
- Trigger In Connector Impedance
  High impedance.
- Edge Trigger {Trigger Determined By}
  Rising (+) or falling (-) edge must be indicated on the **Experiment Setup** ► **Timing** tab {**Trigger** expander}.

6.1.4 Bulb Trigger {Expose During Trigger Pulse} Timing

When Bulb Trigger {Expose During Trigger Pulse} timing is selected, the camera exposure is set by the External Sync input at the **AUX I/O** cable's **TRIGGER IN** connector. This allows an external timing generator to control the exposure time of the camera.

In Full Frame and Kinetics modes, the transition from the inactive state to the active state of the External Sync at the TRIGGER IN connector starts the exposure; and the transition from the active state to the inactive state ends the Expose.

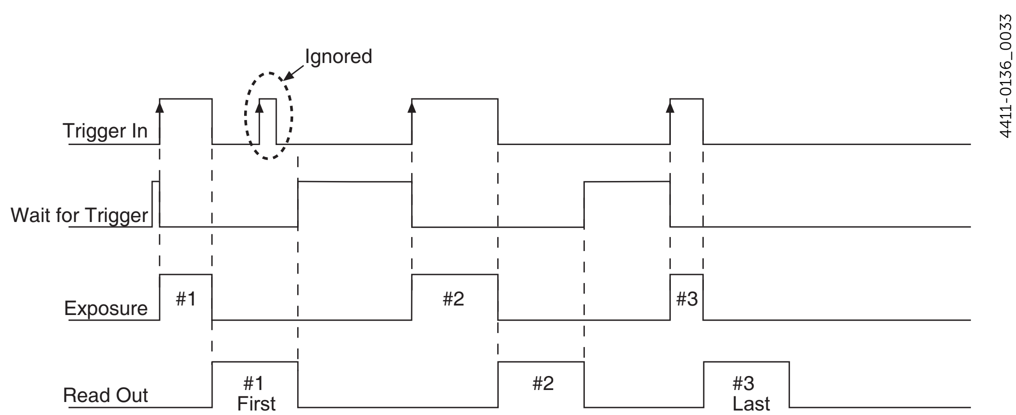
When the camera is ready to accept the external sync through the **TRIGGER IN** connector, the Wait for Trigger {Waiting For Trigger} (WFT) signal at the **AUX I/O** cable's **TTL OUT** connector is high (if WFT is the selected output signal): WFT goes HIGH immediately after readout (or after preopen if it is active). It goes LOW when an active edge (+ or – edge depending on your setting) occurs and, if Continuous Cleans {Clean Until Trigger} is not enabled, the exposure begins. If continuous cleans is enabled, the camera will check for an active edge at the TRIGGER IN connector before entering a continuous clean cycle. If none has occurred, a cycle will begin and complete. The Trigger In connector is checked again to see if an active edge has occurred and exposure will begin if it has.

In Kinetics mode-Multiple Trigger {Shift Per Trigger}, the first exposure is the same as described above. The subsequent exposures really start when WFT on the **TTL OUT** connector goes high. The External Sync on the **TRIGGER IN** connector must then transition to the active state. The exposure will end when the External Sync transitions back to the inactive state.

NOTES:

1. Kinetics mode-Single trigger is not a valid option for Bulb Trigger mode.
2. Continuous Clean is only executed on the first trigger in a sequence. The subsequent triggers will not run the Continuous Clean Programmed pattern.

Figure 6-7: Timing Diagram: Bulb Trigger {Expose During Trigger Pulse}, Non-Overlap Mode, Three Exposure Sequence, No Preopen, No Continuous Cleans



6.2 Fast and Safe Modes

The PyLoN 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 **Safe** data collection is made on the **Experiment Setup ► Timing** tab.
- In LightField, Fast data collections is always used.

Figure 6-8 illustrate the differences between the two modes.

6.2.1 Fast Mode (WinX and LightField)

In Fast operation, the PyLoN runs according to the timing of the experiment with no interruptions from the host computer. Fast operation is primarily for collecting real-time sequences of experimental data where timing is critical and events cannot be missed. Once the PyLoN 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.

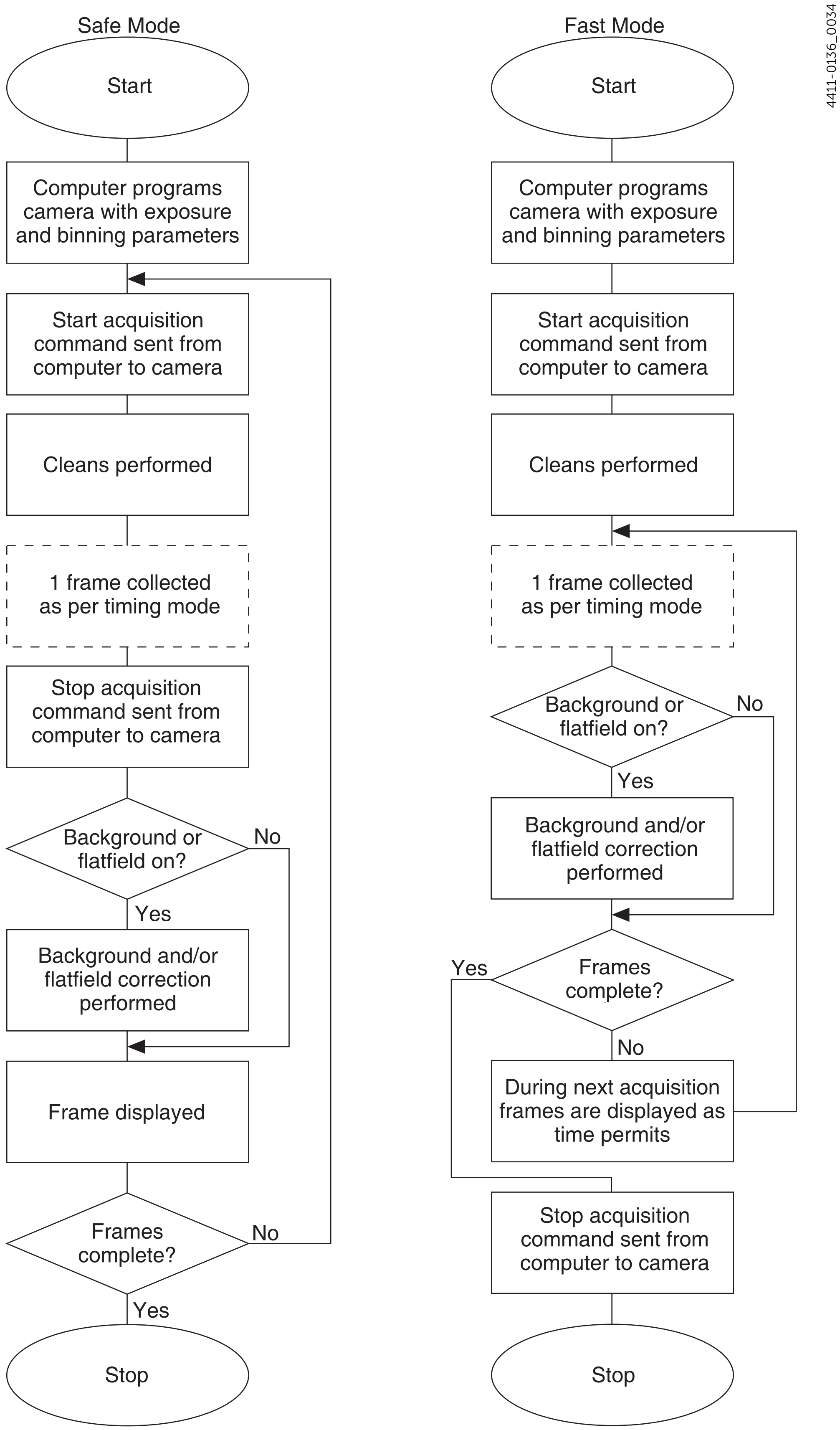
6.2.2 Safe Mode (WinX Only)

In Safe Mode operation, the computer processes each frame as it is received: the PyLoN cannot collect the next frame until the previous frame has been completely processed. 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 6-8, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the camera sends the stop command to the camera, instructing it to stop acquisition. Once that frame is completely processed and displayed, another start 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 camera 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. Refer to Section 6.4, Kinetics Mode, on page 84 for additional information about this type of image acquisition and readout.

Figure 6-8: Safe and Fast Mode Operation Flowcharts

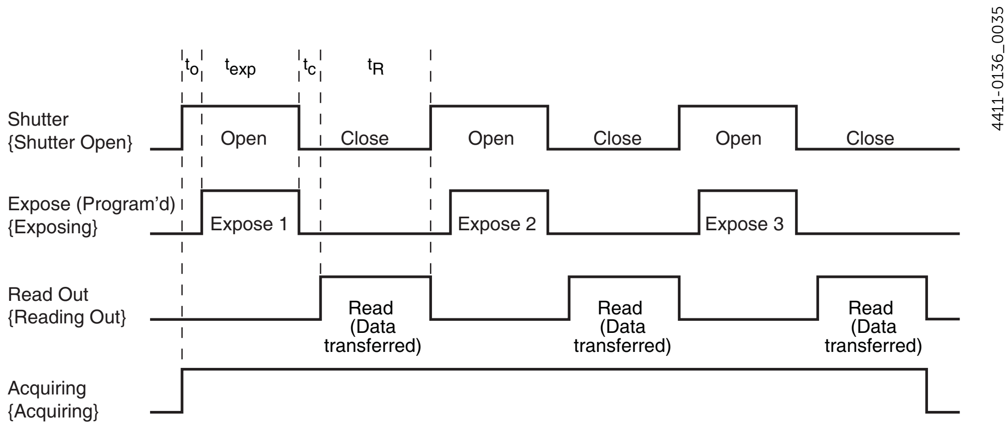


6.3 TTL OUT Control

The TTL-compatible logic level output (0 to +3.3 V_{DC}) from the TTL Out connector on the AUX I/O cable can be used to monitor camera status and control external devices. By default, the TTL output level is high while the action is occurring.

Figure 6-9 illustrates the timing diagram for TTL OUT Control.

Figure 6-9: Timing Diagram: TTL OUT Control



The timing of the level changes depends on the output type selected on the **Hardware Setup** ► **Controller/Camera** tab {**Trigger** expander}:

- Acquiring {Acquiring}

  After a start acquisition command, this output changes state on completion of the array cleaning cycles that precede the first exposure. Initially low, it goes high to mark the beginning of the first exposure. In free run operation it remains high until the system is halted. If a specific number of frames have been programmed, it remains high until all have been taken and then returns low. Figure 6-9 assumes 3 frames have been programmed.
- Expose (Effective) {Effectively Exposing}

  This level is at a logic high during the effective exposure time. For a full frame PyLoN, Expose (Effective) and Expose (Program'd) are identical.
- Expose (Program'd) {Exposing}

  This level is at a logic high during the programmed exposure time (i.e., the time set in the software). It can be used to synchronize a pulser or timing generator with exposure.
- Image Shift {Shifting Under Mask}

  For a full frame camera, this level is at a logic high while an image row is being shifted toward the serial register. When in kinetics mode, the level is high when a subframe is shifted under the optical or mechanical mask; but, after the CCD is filled, Image Shift reverts to going high each time a row is shifted into the serial register.
- Logic 1 {Always High}

  The level at the connector is high.
- Read Out {Reading Out}

  It is at a logic high when CCD is being read; otherwise low.

- Shutter {Shutter Open}
  This level is at a logic high while the shutter is opening and during the programmed exposure time. The output precisely brackets shutter-open time (exclusive of the shutter close compensation time t_c) and can be used to control an external shutter.
- Wait for Trigger {Waiting For Trigger}
  This level is at a logic high when the camera is ready to acquire and is waiting for an external trigger (through the TRIGGER IN connector) before exposing the CCD. The level goes low when a trigger is detected: exposure begins. The Wait for Trigger (WFT) signal goes high immediately after readout or after Preopen {Open Before Trigger} (if it is active). If continuous cleans is enabled, the camera will check for a trigger at the TRIGGER IN connector before entering a continuous clean cycle. If none has occurred, a cleaning cycle is initiated and completed. Before the next cycle begins, the TRIGGER IN connector is checked again, and exposure will start if a trigger has occurred.

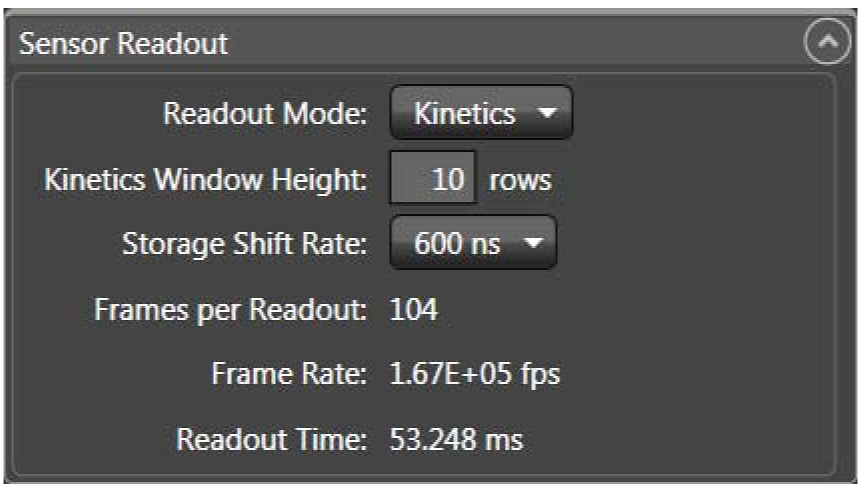
When the **Invert LOGIC** {**Invert Output Signal**} box is checked, the output is at a logic low when the action is occurring.

6.4 Kinetics Mode

Kinetics refers to a special readout mode in which a portion of the CCD is illuminated while the rest of the active area is used to store a series of frames. At the end of the exposure-shift sequence, the entire CCD is readout to give a series of subframes (kinetic frames) separated in time. In order to support this special mode of operation, it is essential that the camera architecture be made flexible with special access to underlying CCD control functions Aided by the back illumination technology for high QE and multiplication gain for sub-electron read noise, the kinetics mode provides the powerful combination of speed and sensitivity.

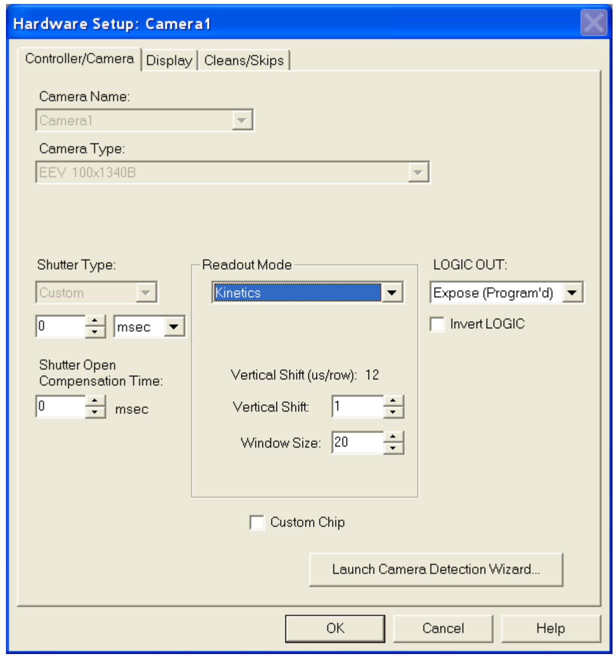
Figure 6-10 and Figure 6-11 illustrate the configuration expander and dialog for Kinetics mode in LightField and WinX, respectively.

Figure 6-10: Sensor Readout Expander: Kinetics Readout Mode



4411-0136_0036

Figure 6-11: Hardware Setup Dialog: Kinetic Readout Mode



6.4.1 Kinetics Readout

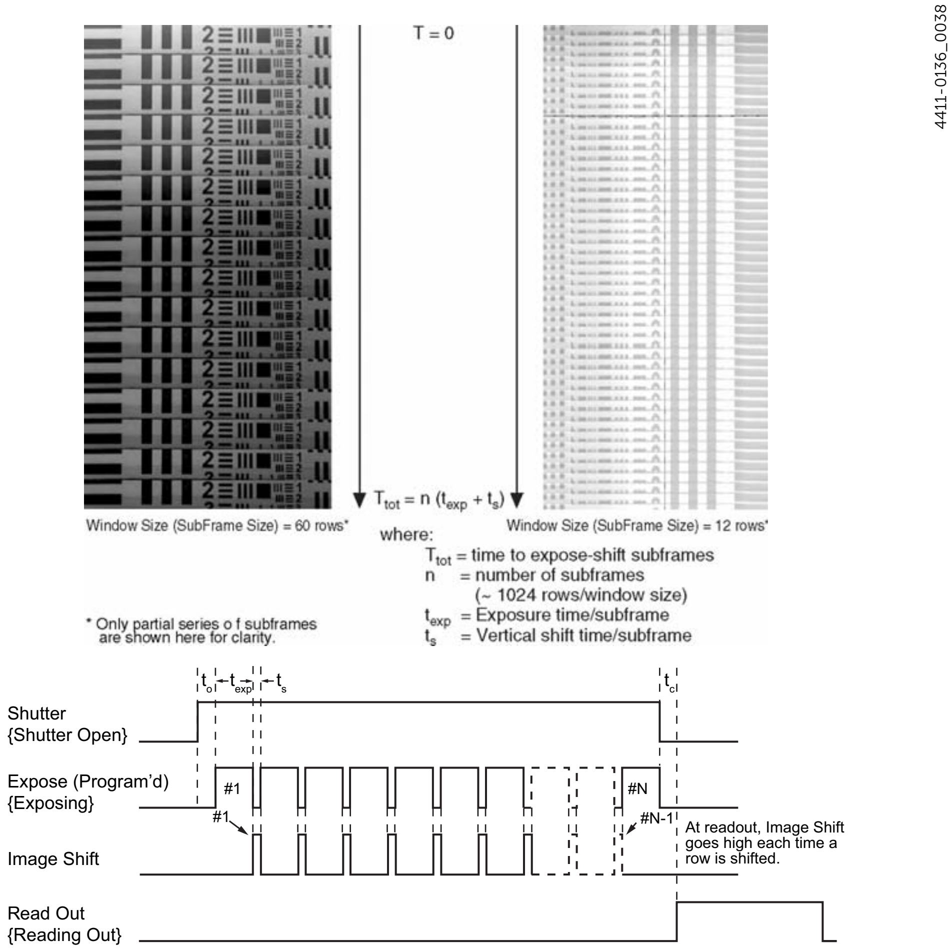
Kinetics readout allows a burst of subframes to be captured with μsec resolution. This is accomplished by shifting each subframe exposure under the mask before reading it out. Since there is no overhead of readout time between each exposure, faster time resolution is achieved. Following a series exposure-shift cycles, the entire frame is typically read out at a slower readout speed, which does not affect the time resolution.

In kinetics mode, a portion of the CCD image is optically masked in order to minimize the cross-talk between subframes. Typically, in imaging applications, this is accomplished by placing a knife edge or an optical mask in the collimated beam path. In spectroscopy this is best achieved by limiting the height of the entrance slit of the spectrograph. For most applications, the ability to mask as few rows as possible sets the ultimate limit on the temporal resolution. Figure 6-12 illustrates this with examples acquired using an optical test target image.

NOTES:

1. The timing diagram represents the exposure-readout sequence. Time resolution between subframes is given by $t_{exp} + t_s$.
2. A reduced number of rows in the right image illustrates how to achieve better time resolution between subframes.

Figure 6-12: Kinetics Data Acquired Based on Masked Images

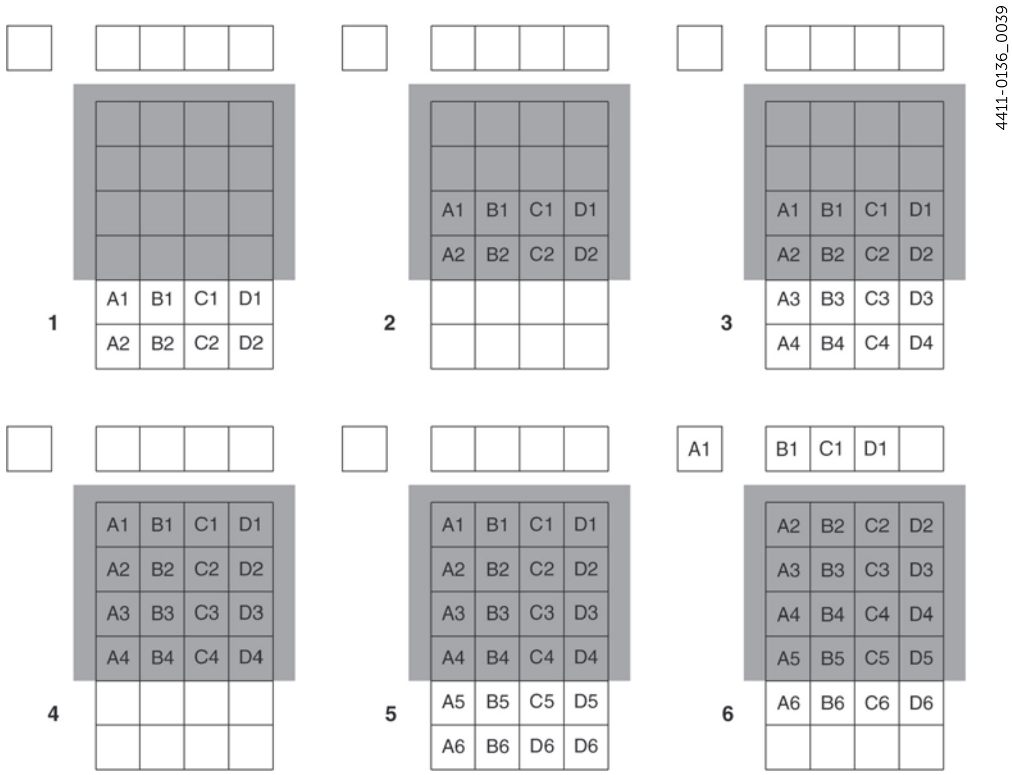


TTL OUT Signal Descriptions:

- Shutter
  High during:
  Shutter open comp + All Exposures + Shift Cycles
  Follows Disabled Open or Disabled Closed.
- Expose (Program'd)
  High during programmed exposure as configured within software.
- Image Shift
  High during:
  Subframe shift under mask
  At readout, goes high when a row is read into the register.
- Read Out
  High during:
  Vertical Transfer + Digitization

Figure 6-13 illustrates a simplified depiction of kinetics mode using a 4 x 6 CCD. In this case 2/3 of the array is masked, either mechanically or optically. The shutter opens to expose a 4 x 2 region. During the time the shutter remains open, charge is quickly has been is acquired, 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 illustrated in

Figure 6-13: Kinetics Readout



6.4.2 Kinetics Timing Modes and Shutter Control

For Kinetics, the timing modes are 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 TRIGGER IN connector on the I/O cable. The camera can be triggered either on +Vertical Edge {Positive} or -Vertical Edge {Negative} of the incoming TTL pulse.

In the Free Run Kinetics mode, the PyLoN 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; and on the Common Acquisition Settings expander in LightField,). 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 inter-image 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 MON) or Readout signals (READOUT MON) are provided at the AUX I/O connector for timing measurements.

The Shutter Control options are Normal, PreOpen {Open Before Trigger}, Disabled Open {Always Open} and Disabled Closed {Always Closed}. Normal means that the Shutter opens at the beginning of the first exposure-shift kinetics cycle and closes at the end of the last exposure-shift cycle. Disabled simply means that the shutter will not operate during the experiment. Disabled closed is useful for making dark charge measurements. PreOpen {Open Before Trigger}, available in the External Sync and External Sync with Continuous Cleans {Clean Until Trigger} modes, opens the shutter as soon as the PyLoN 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.

6.4.3 Triggered Operation

The choice of trigger (Single or Multiple) is made on the **Experiment Setup ► Timing** tab in WinX. The equivalent choice (Readout Per Trigger or Shift Per Trigger) is made on the **Trigger** expander in LightField. In Single Trigger {Readout Per Trigger} mode, the camera requires only one trigger to initiate an entire series of "exposure-shift" cycles as shown in the timing diagram shown in Figure 6-14. Here, the camera uses the exposure time as entered into the software. The trigger is applied at the **TRIGGER IN** connector of the AUX I/O cable. In Multiple Trigger mode {Shift Per Trigger}, each "exposure-shift" cycle is triggered independently by a pulse applied at the **TRIGGER IN** connector. This mode is useful when each subframe needs to be synchronized with a pulsed external light source such as a laser.

NOTES:

1. It is recommended in LightField that the Number of Frames setting be equal to the height of the array divided by the Kinetics Window Height (e.g., for a 1340 x 100 sensor and a Kinetics Window Height of 5, the Number of Frames would be 20.)
2. It is important to keep ambient light to a minimum while Multiple Trigger {Shift Per Trigger} mode is used. In the case of this mode, automatic cleaning of the CCD only occurs until the first trigger arrives. Once the series of exposure-shift cycles begins, cleaning does not occur and, at the end of a cycle, ambient light will be collected through the window until the next trigger arrives. Depending on the time between triggers and the amount of ambient light, some sub-frames may appear brighter than others.

Figure 6-14: Timing Diagram: Kinetics Operation Using Single Trigger

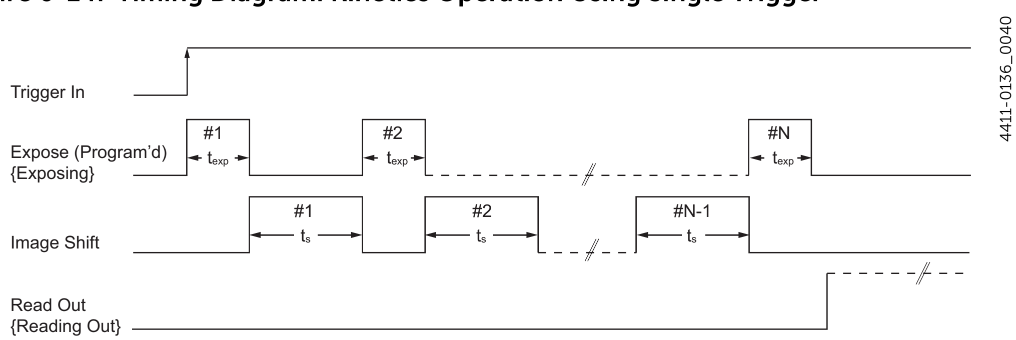
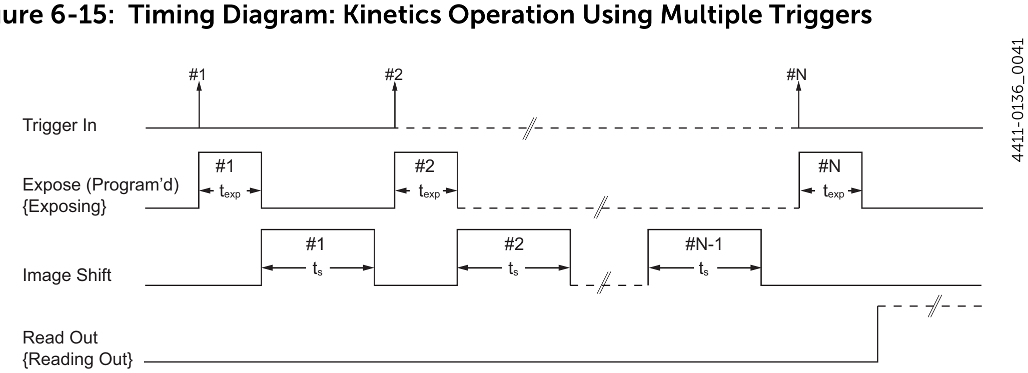


Figure 6-15: Timing Diagram: Kinetics Operation Using Multiple Triggers



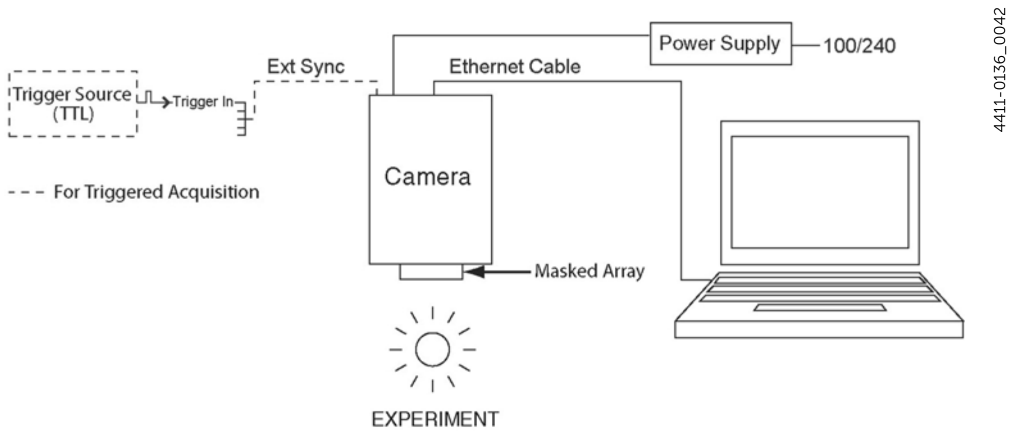
6.4.4 Cleaning the CCD

Since kinetics is most often used in asynchronous, single-shot experiments, it is important that CCD be cleared of accumulating background or dark charge while it is waiting for an external trigger. To take care of this, PyLoN automatically cleans the CCD “one row at a time” before the arrival of the first trigger. This keeps the charge buildup on the CCD to a minimum at the same time minimizing the timing jitter (determined by vertical shift time of a single row). If desired, the number of cleans can be set to zero for the best jitter performance. However, the camera must be in a dark environment to minimize the background.

6.4.5 Setting up a Kinetics Experiment

This section provides information about setting up a Kinetics experiment. Figure 6-16 is a block diagram of a typical Kinetics experiment.

Figure 6-16: High Level Block Diagram of a Typical Kinetics Experiment



This procedure assumes that:

- You have already set up your system in accordance with the instructions in the previous chapters.
- You have read the previous sections of this chapter.
- You are familiar with the application software.
- The system is being operated in imaging mode.
- 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.
- You are only illuminating a portion of the CCD.
- You are using either WinX or LightField. WinX parameter setup is presented first; LightField, second.

6.4.5.1 Configure Software Parameters in WinX

NOTE:

This procedure is based on using WinSpec/32. If using a different application, modifications may be required based on that 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.

Configure WinX software parameters as follows:

- **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:** This information is read from the camera.
  - **Readout mode:** Available modes are read from the camera. Select **Kinetics**.
  - **Window Size:** Enter the number of exposed rows.
- **Cleans tab (Setup ► Hardware):** Automatically set.
- **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**.
- **Experiment Setup ► Main tab (Acquisition ► Experiment Setup...):**
  - **Exposure Time:** 100 μsec
  - **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.
  - 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, Single Trigger, or Multiple Trigger
  - **Shutter Control:** Normal
  - **Safe Mode vs. Fast Mode:** Safe Mode must be selected for Kinetics mode operation.

6.4.5.2 Configure Software Parameters in LightField:

NOTE:

This procedure is based on using LightField. If using a different application, modifications may be required based on that application. Basic familiarity with the LightField32 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.

Configure LightField parameters as follows:

- **Sensor Readout expander:** These parameters should be set automatically to the proper values for your system.
  - **Readout Mode:** Available modes are read from the camera. Select **Kinetics**.
  - **Kinetics Window Height:** Enter the number of exposed rows.
- **Temperature Setpoint (Sensor expander):** The default temperature setting is read from the camera. When the array temperature reaches the set temperature, that status will be reported as **Locked** in the Sensor expander and in the Status bar.
- **Common Acquisition Settings expander:**
  - **Exposure Time:** 100 μsec
  - **Number of Frames: 1**
  - **Exposures per Frame:** 1
- **Sensor Readout Region expander:** Use the functions on this expander to define the region of interest (ROI).
  - Clicking on **Full Sensor** selects the full window (without binning)
- **Shutter expander:**
  - **Shutter Mode:** Normal
- **Trigger expander:**
  - **Trigger Response:** No Response, Readout Per Trigger, or Shift Per Trigger

6.4.6 Summary

Kinetics mode is a powerful feature that allows a burst of subframes to be captured with microsecond time resolution. However, careful attention must be paid to the optical and timing considerations, particularly:

- The rows furthest from the serial register need to be illuminated.
- The rest of the active area must be optically masked.
- Single trigger {Readout Per Trigger} mode allows the capture of a burst of frame with just one trigger.
- In multiple trigger {Shift Per Trigger} mode, the camera requires a trigger for each exposure-shift cycle.
- The highest time resolution between kinetic frames is determined by the window (subframe) size.
- Acquisition must be in Safe Mode if you are using WinSpec or WinView.
- Binning and ROI selections are supported as in the standard operation.

6.5 Custom Modes

Custom Chip mode is available as an option for the WinX applications; {Custom Sensor} and Custom Timing are standard {sensor-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.

6.5.1 Custom Chip {Custom Sensor}

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.

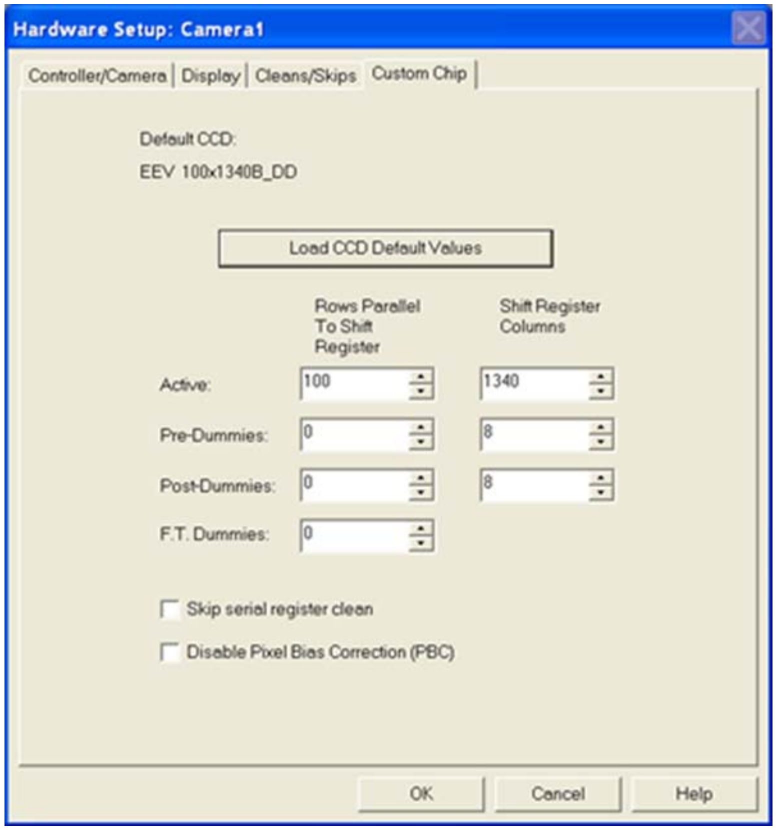
6.5.1.1 Software Settings

CAUTION!

Teledyne Princeton Instruments does not encourage users to modify 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 illustrated in Figure 6-17. The default values conform to the physical layout of the CCD array and are optimum for most measurements.

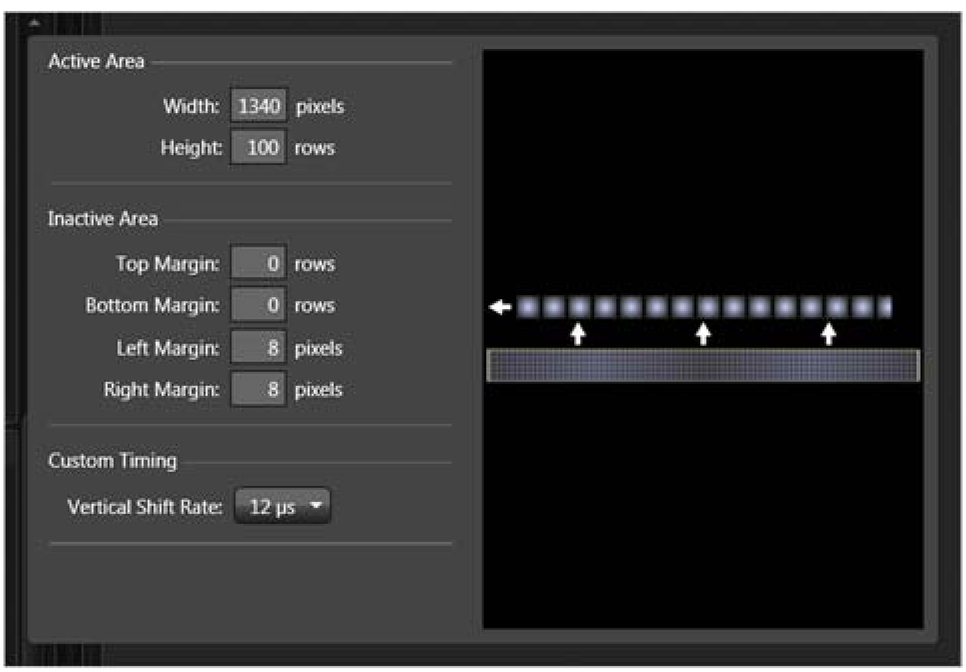
Figure 6-17: Typical WinX Custom Chip Tab



4411-0136_0043

In LightField, the Custom Sensor pane, illustrated in Figure 6-18, is accessed by opening the Sensor expander and clicking on the Custom Sensor button.

Figure 6-18: Typical LightField Custom Sensor Panel



4411-0136_0044

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 when there are no Pre-Dummy rows, the register clean out will be skipped and the chip readout will be faster. This feature is not available for PVCAM-supported cameras.

NOTE:

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

6.5.2 Custom Timing

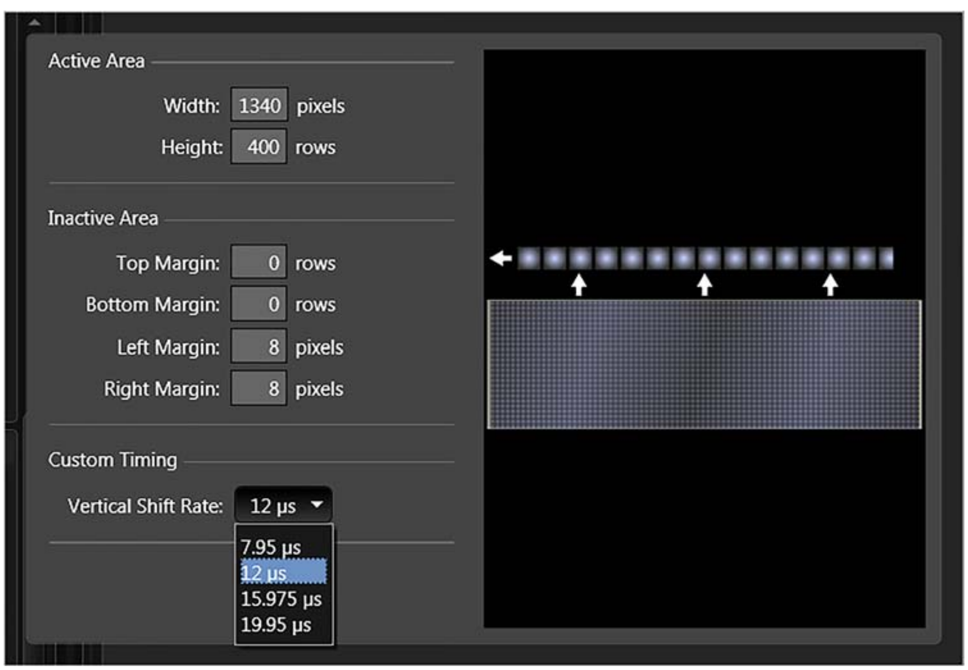
NOTE:

This mode is standard with LightField for a PyLoN full frame CCD camera.

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 as illustrated in Figure 6-19.

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.

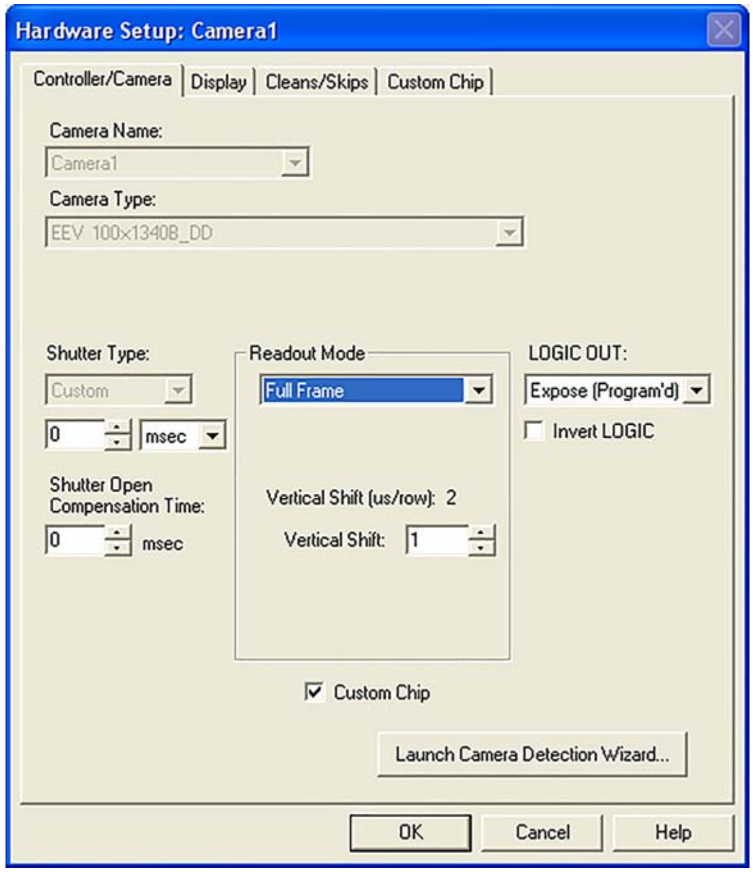
Figure 6-19: Typical LightField Custom Timing Dialog



4411-0136_0045

In WinX, the equivalent function is located on the Camera/Controller tab on the Hardware Setup dialog. See Figure 6-20.

Figure 6-20: WinX Vertical Shift Dialog



Chapter 7: Troubleshooting

WARNING!
Do not connect or disconnect any cables while the PyLoN system is powered on.

Recommended troubleshooting procedures are available for many issues that may occur when working with a PyLoN system. Refer to Table 7-1 for additional information.

Table 7-1: Issues with Recommended Troubleshooting Procedures

7.1 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 (also remove liquid nitrogen from the camera, if appropriate) and have the camera repumped before resuming normal operation. Immediately contact Customer Support for further instructions. Refer to Contact Information on page 130 for complete information.

7.2 Camera Stops Working

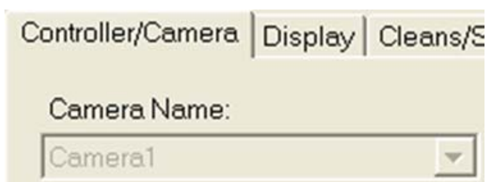
Problems with the host computer system or software may have side effects that appear to be hardware problems. If you are sure the problem is in the camera system hardware, begin with these simple checks:

1. Turn off all AC power.
2. Verify that all cables are securely fastened and that all locking screws are in place.
3. Correct any apparent problems and turn the system on.
4. If the system still does not respond, contact Customer Support.

7.3 Camera1 (or similar name) on Hardware Setup Dialog

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. See Figure 7-1.

Figure 7-1: Camera1 in Controller Type (Camera Name) Field



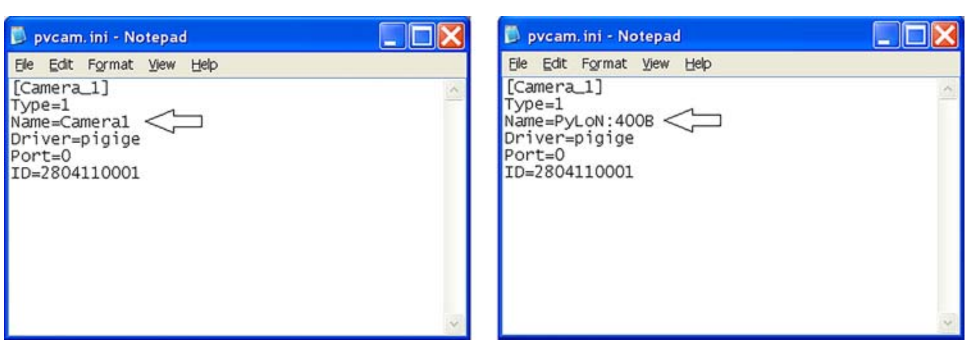
4411-0136_0047

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.

Perform the following procedure to change the default Camera Name:

1. Close the application program if it is running.
2. Using Notepad (or equivalent text editor,) open `pvcam.ini` from the **Windows** directory.
3. Edit the **Name**. See Figure 7-2.

Figure 7-2: Editing Camera Name in `pvcam.ini` Using Notepad

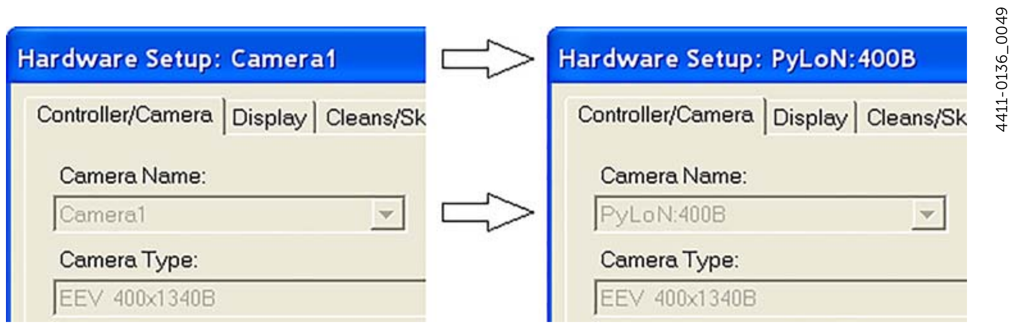


4411-0136_0048

4. Save the edited file.

   The next time WinX is launched, the new name will be displayed on the **Hardware Setup** dialog as shown in Figure 7-3.

Figure 7-3: Typical Hardware Setup Dialog with Renamed Camera



NOTE:

If the Camera Detection Wizard is run at a later time, the camera's name will revert to the default name (i.e., Camera1).

7.4 Cooling Troubleshooting

This section describes issues and faults related to cooling.

7.4.1 Temperature Lock Cannot be Achieved or Maintained

Possible causes include:

- The vacuum has deteriorated and needs to be refreshed.
- The target array temperature is not appropriate for your particular camera and CCD array.

7.4.2 Camera loses Temperature Lock

The internal temperature of the camera is too high.

This might occur if:

- The operating environment is particularly warm;
- Attempting to operate at a temperature colder or warmer than the specified limit;
- There is not enough LN in the Dewar.

Refill the Dewar and verify that temperature lock can now be achieved.

If you are still having a problem, contact Customer Support for further instructions. Refer to Contact Information on page 130 for complete information.

7.4.3 Gradual Deterioration of Cooling Capability

With time, there will be a gradual deterioration of the camera’s vacuum. This, in turn, will eventually affect temperature performance and it may no longer be possible to achieve temperature lock at the lowest temperatures. In the kind of low-light applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system’s temperature performance because lower temperatures provide less thermal noise and better signal-to-noise ratio.

Vacuum deterioration occurs primarily as a result of outgassing of components in the vacuum chamber. Because outgassing normally diminishes with time, the rate of vacuum deterioration in new cameras will be faster than in old ones. When the camera no longer maintains an acceptable cold temperature, contact Customer Support to make arrangements to return the camera to have the vacuum restored. Refer to Contact Information on page 130 for complete information.

WARNING!
Do not open the vacuum valve under any circumstances.
Opening the vacuum valve will void your warranty.

7.5 Common Program Errors

This section provides information about troubleshooting common program errors.

7.5.1 Data Overrun Due to Hardware Conflict

Figure 7-4 illustrates the error dialog that is displayed 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).

Figure 7-4: Typical Data Overrun Due to Hardware Conflict Dialog

4411-0136_0050

Perform the following procedure 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.
   - If DMA memory is currently configured to 32 MB, increase it to 64 MB;
   - If DMA memory is currently configured to 64 MB, increase it to 128 MB.
4. Click **OK**.
5. Close WinSpec.
6. Reboot the host computer.
7. Launch WinSpec and begin acquiring data or focusing. If the message is displayed again, increase the DMA buffer size.

7.5.2 Program Error

The dialog illustrated in Figure 7-5 may be displayed when attempting to acquire a test image, acquire data, or run in focusing mode when the DMA buffer size is too small. A large array (e.g., a 2048 x 2048 array,) requires a larger setting than a smaller array requires (e.g., a 512 x 512 array).

Figure 7-5: Typical Program Error Dialog

4411-0136_0051

Perform the following procedure to correct this issue:

1. Click **OK** to dismiss the error dialog.
2. Reboot WinSpec.
3. Note the array size on the **Setup** ► **Hardware** ► **Controller/CCD** tab or the **Acquisition** ► **Experiment Setup** ► **Main** tab Full Chip dimensions.
4. Open **Setup** ► **Environment** ► **Environment** dialog.
5. Increase the DMA buffer size to a minimum of 32 MB.
   - If DMA memory is currently configured to 32 MB, increase it to 64 MB;
   - If DMA memory is currently configured to 64 MB, increase it to 128 MB.
6. Click **OK**.
7. Close WinSpec.
8. Reboot the host computer.
9. Launch WinSpec and begin acquiring data or focusing. If the message is displayed again, increase the DMA buffer size.

7.5.3 Serial Violations Error

The error message shown in Figure 7-6 will be displayed when attempting to acquire an image or focus the camera, and when 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.

> **NOTE:**
> The same error message will be displayed if the camera system is turned off or a cable comes loose while the application software is running in Focus mode.

Figure 7-6: Typical Serial Violations Have Occurred Dialog

4411-0136_0052

Perform the following procedure to correct this problem:

1. Turn the camera system off if it is not already off.
2. Verify the computer interface cable is secure at both ends.
3. Turn the camera system power on.
4. Click **OK** on the error message dialog.
5. Attempt to acquire an image or running in focus mode.

7.6 Ethernet Network is Not Accessible

When the Teledyne Princeton Instruments software is installed, all Intel Pro/1000 interface card drivers found on the host computer are updated with the Intel Pro/1000 Grabber Adapter (Vision High-Performance IP Device) driver provided by Pleora Technologies, Inc.

If the host computer is connected to an Ethernet network via an Intel Pro/1000 card that does not use the Pleora driver, the network connection will be broken. The tool used to restore the network connection depends on whether WinX (32-bit) or LightField (64-bit) is being used.

7.6.1 Using WinX

Perform the following procedure:

1. Obtain the EbDriverTool32.exe file by one of the following methods:
   - Download the `EbDriverTool32.exe` file to the host computer from:

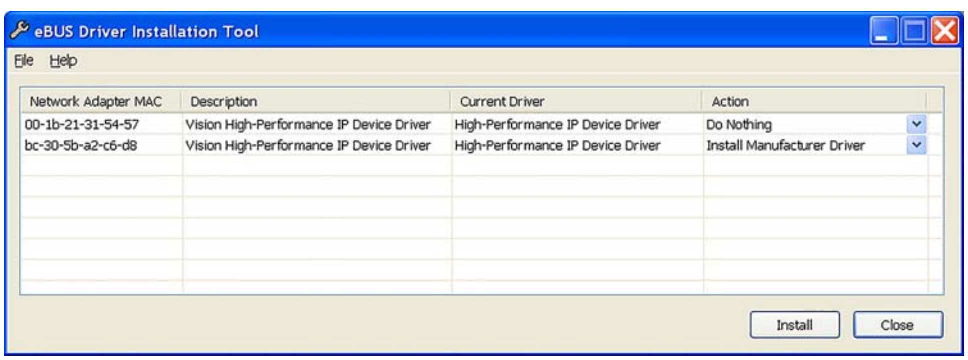
     ftp://ftp.princetoninstruments.com/public/Software/Official/WinX32/GigE/
   - Open the default Pleora directory which is typically on the host computer at:

     `C:\Program Files\Common Files\Pleora`

     The `EbDriverTool32.exe` (or `EbDriverTool.exe`) file may be stored in a subdirectory.
2. Execute the program file.
3. When prompted, select the appropriate Ethernet card, and under the **Action** column, select **Install Manufacturer Driver** from the pull-down menu.

   See Figure 7-7.

Figure 7-7: Typical 32-Bit eBUS Driver Installation Tool Dialog



4411-0136_0053

4. After making the selection, click **Install**.
5. After the installation you may be prompted to reboot the computer.

   When prompted, either:
   - Click **Yes** to initiate the reboot;
   - Click **No** to delay rebooting.

     When selecting **No**, it may be necessary to close the **eBUS Driver Installation Tool** dialog. The host computer may be rebooted when convenient.
6. Verify that the network connection has been re-established.

   If a reboot was required, wait until the reboot is complete before verifying the connection.

7.6.2 Using LightField

Perform the following procedure:

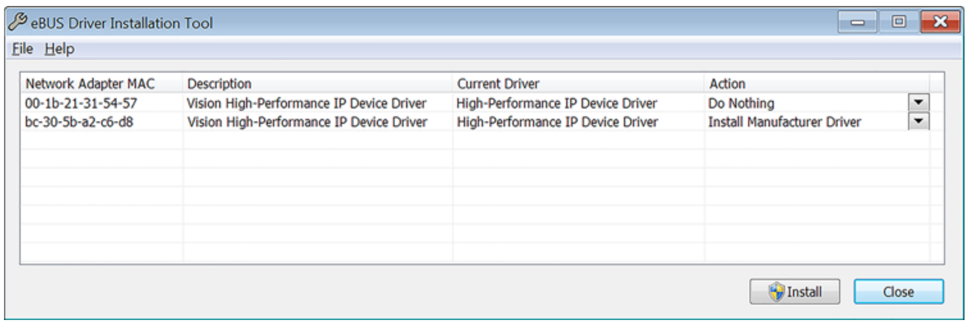
1. Locate the `EbDriverTool64.exe` file. Typically it is located on the host computer in the following directory:

   `C:\Program Files\Common Files\Pleora`

   The `EbDriverTool64.exe` file may be in a subdirectory.
2. Execute the program file.
3. When prompted, select the appropriate Ethernet card, and under the **Action** column, select **Install Manufacturer Driver** from the pull-down menu.

   See Figure 7-8.

Figure 7-8: Typical 64-Bit eBUS Driver Installation Tool Dialog



4411-0136_0054

4. After making the selection, click **Install**.
5. After the installation you may be prompted to reboot the computer.

   When prompted, either:
   - Click **Yes** to initiate the reboot;
   - Click **No** to delay rebooting.

     When selecting **No**, it may be necessary to close the **eBUS Driver Installation Tool** dialog. The host computer may be rebooted when convenient.
6. Verify that the network connection has been re-established.

   If a reboot was required, wait until the reboot is complete before verifying the connection.

7.7 Overexposed or Smeared Images

If the camera has an internal shutter, determine if 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 open, thus causing overexposed or smeared images;
- The shutter may remain closed resulting in no image being acquired;
- One leaf of the shutter may break and will 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 for information about shutter replacement. Refer to Contact Information on page 130 for complete information.

NOTE:

Shutters are not covered by the warranty.

7.8 Shutter Failure

Refer to Section 7.7, Overexposed or Smeared Images, on page 104.

7.9 Vignetting

All CCD arrays have been tested for uniformity and do not exhibit any vignetting (reduction of response) at the extreme ends of the array. If you do measure such reduction in response across the array, it may be the result of one or more of the following conditions:

- Condensation of water on the edges of the array window has occurred. This should not happen unless the cooling/pumping instructions, previously mentioned, were not followed or if the Dewar has developed a vacuum leak (a rare situation).
- The arrays are held with a special mask that has been designed to minimize reflection and stray light. These masks were designed to allow light rays to enter through the Dewar window even at very wide angles ($\geq$ f/1.5.) If vignetting is observed, it is possible that your experiment exceeds these angular constraints. Teledyne Princeton Instruments measures the array response with a collimated uniform light source to prevent such false bias results.

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Appendix A: Technical Specifications

CAUTION!
All specifications are subject to change.

This appendix provides some technical information and specifications for PyLoN cameras and optional accessories. Additional information may be found on data sheets available on the Teledyne Princeton Instruments website (www.princetoninstruments.com).

A.1 Minimum Host Computer Specifications

The minimum host computer specifications are:

- Type

  2 GHz Pentium® 4 (or greater).
- Operating System

  For WinSpec:
  - Windows XP (SP3 or later)
  - Vista (32-bit)

  For LightField
  - Windows 7 (64-bit)
  - Vista (64-bit)
- Memory (RAM)

  2 GB RAM (or greater).
- Drives:
  - CD-ROM drive
  - Hard disk with a minimum of 1 GB available.

    A complete installation of the program files requires approximately 50 MB with the remaining space required for data storage which is dependent upon the number and size of images/spectra collected.

    Disk level compression programs are not recommended.

    Drive speed of 10,000 RPM recommended.
- Available Card Slot

  At least one unused PCI card slot (PCI 2.3 compliant 32-bit 33/66 MHz bus).
- Interface

  Intel® PRO/1000 card is supplied with the PyLoN system.
- Monitor

  Super VGA monitor and graphics card supporting at least 65535 colors with at least 128 MB of memory.

  Memory requirement is dependent on desired display resolution.

A.2 Camera

- CCD Arrays
  Teledyne Princeton Instruments offers a wide-variety of CCDs for spectroscopy.
  Contact Teledyne Princeton Instruments or visit www.princetoninstruments.com for an up-to-date list of arrays supported by the PyLoN.
- Window
  Fused silica vacuum window. Anti-reflection coatings for various wavelength ranges are available.
- Controller Type
  Internal
- Inputs
  - AUX I/O
    The TRIGGER IN TTL input (BNC) on the AUX I/O cable to allow data acquisition to be synchronized with external events.
    Can be positive or negative going as set in software.
    Synchronization and Trigger Modes are discussed in Chapter 6, Advanced Topics, beginning on page 75.
    Figure A-1 illustrates a typical AUX I/O cable. The leads on the AUX I/O cable are color coded. Refer to Table A-1 for pinout information.

REFERENCES:

Refer to Section A.3, AUX I/O Connector, on page 111 for additional information about these and other available I/O signals.

Figure A-1: Typical AUX I/O Cable (P/N: 6050-0681)

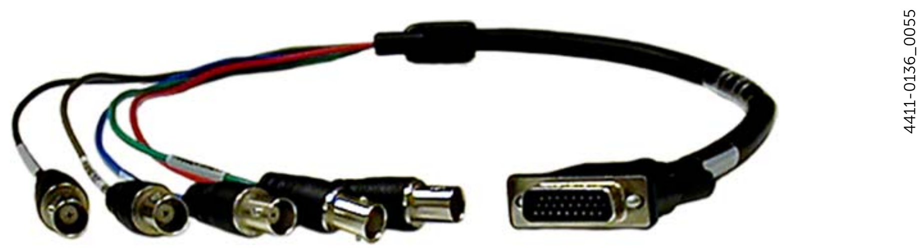


Table A-1: AUX I/O Cable Pinout

Name	Color	Pin Center	Pin Return
TRIGGER IN	Red	Pin 1	Pin 3
TTL OUT	Green	Pin 2	Pin 6
READOUT MON	Blue	Pin 7	Pin 18
EXPOSE MON	Gray	Pin 8	Pin 20
SHUTTER MON	Black	Pin 23	Pin 25

- Outputs:
  - Gig-E
    Gigabit Ethernet connector
  - AUX I/O
    The AUX I/O connector and cable (6050-0681) also provide access to the following output signals:
    - TRIGGER IN;
    - TTL OUT;
    - READOUT MON;
    - EXPOSE MON;
    - SHUTTER MON.

    Figure A-1 illustrates a typical AUX I/O cable. The leads on the AUX I/O cable are color coded. Refer to Table A-1 for pinout information.

REFERENCES:

Refer to Section A.3, AUX I/O Connector, on page 111 for additional information about these and other available I/O signals.

- A/D Converter
  Software-selectable digitization rates:
    - 50 kHz;
    - 100 kHz;
    - 200 kHz;
    - 500 kHz;
    - 1 MHz;
    - 2 MHz;
    - Plus one of the following additional rates: 3 MHz; 4 MHz; or 5 MHz.
  - Linearity
    Better than 1%.
  - Readout noise
    1-1.2 counts RMS.
- Temperature Control
  - Setting Mechanism
    Temperature is set by the application software.
  - Display
    The actual temperature can be displayed at the computer by the application software.
  - Stability
    $\pm$0.05°C thermostatting precision
  - Temperature Range
    Typically -70° C to -120° C
  - Time to Lock
    ~1 - 2 hours for cryogenic.
- Exposure (integration) Time
  0 or 1 μs (shutter) to 2.3 hours (full frame)

- Internal Camera Shutter (optional)
  1.59 in (40 mm) aperture, 28 ms open time, 28 ms close time.
- External Shutter (optional)
  0.9 in (23 mm) aperture, 8 ms open time, 8 ms close time
- Shutter Compensation Time

Table A-2: Shutter Compensation Time

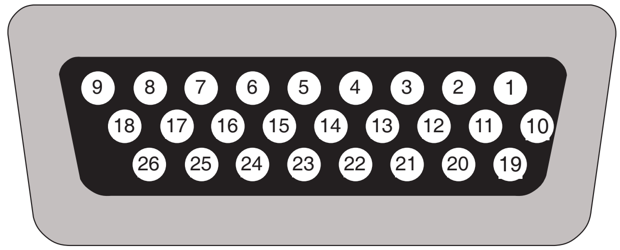
Shutter	Exposure
40 mm or larger (large Teledyne Princeton Instruments supplied internal shutter)	28.0 ms
25 mm or smaller (Teledyne Princeton Instruments supplied external shutter)	8.0 ms
No shutter	200 ns

- Mechanical Focal Depth
  — Non-shuttered: 0.549”
  — Shuttered: 0.894"
- Environmental Requirements
  — Storage temperature: <55°C
  — Operating environment: 5°C < T < 30°C
  — Relative humidity: ≤50%; non-condensing
- Miscellaneous
  — Dimensions: Refer to Appendix B, Outline Drawings, on page 113.
  — Power Supply Weight: 13 lb (5.9 kg)
  — Power Requirements: Nominally 100, 120, 220 or 240 V_{AC}.

A.3 AUX I/O Connector

Figure A-2 shows the pinout for an AUX I/O connector.

Figure A-2: AUX I/O Connector Pinout



The AUX I/O (Input/Output Status) connector provides information about trigger function, DAC, and TTL signals. Inputs must be at least 2.4 V for a TTL high and less than 0.9 V for a low.

The numbers on the I/O connector diagram correspond to the numbers given to the definition of each of the pins. The AUX I/O connector is a female, DB26, high-density connector. The AUX I/O cable (P/N: 6050-0681) provides access to TRIGGER IN (Pin 1), TTL OUT (Pin 2), READOUT MON (Pin 7), EXPOSE MON (Pin 8), and SHUTTER MON (Pin 23).

Refer to Table A-3 for complete AUX I/O pinout information.

Table A-3: AUX I/O Pinout Information (Sheet 1 of 2)

Pin #	Signal Description
1	TRIGGER IN: 0 to +3.3 V logic level input (TTL-compatible) that has a 25 kΩ pull-up resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) edge triggering can be selected.
2	TTL OUT: 0 to +3.3V programmable logic level output (TTL-compatible). The output of this connector can be selected and can also be inverted via the application software.
3	GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection.
4	DAC1: 10-bit programmable output (0 – 2.5 V). 100 Ω source impedance.
5	DAC2: 10-bit programmable output (0 – 2.5 V). 100 Ω source impedance.
6	GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection.
7	READOUT MON: Active high. A high level on this output indicates that data is being readout of the array.
8	EXPOSE MON: Active high. A high level on this output indicates that the camera is exposing (integrating).
9	TTL I/O LATCH ENABLE: Logic “1”, TTL I/O inputs are monitors; Logic “0”, TTL I/O inputs are latched on the negative transition.
10	TTL I/O data bit 0: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).

Table A-3: AUX I/O Pinout Information (Sheet 2 of 2)

Pin #	Signal Description
11	TTL I/O data bit 1: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
12	TTL I/O data bit 2: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
13	TTL I/O data bit 3: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
14	TTL I/O data bit 4: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
15	TTL I/O data bit 5: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
16	TTL I/O data bit 6: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
17	TTL I/O data bit 7: TTL level programmable input or output. 16-bit register, with 8 LSB for data and 8 MSB controlling I/O direction (Logic 1: corresponding data bit is an output; Logic 0 the bit is an input).
18	GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection.
19	Power Status: A high level on this output indicates that the camera power is switched on (+3.3 V = on, 0 V = off).
20	GND: System chassis ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection.
21	Reserved for Future Use: DO NOT USE
22	Reserved for Future Use: DO NOT USE
23	SHUTTER MON: The level at this output is high while the shutter is opening and during the programmed exposure time. The output precisely brackets shutter-open time (exclusive of the shutter close compensation time t_c) and can be used to control an external shutter.
24	HEATER ENABLE: Open or Logic "1" will enable the heater; Logic "0" will disable the heater.
25	GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection.
26	GND: System digital ground. Any external circuitry intended to interface with the trigger control signals must reference this ground connection.

Appendix B: Outline Drawings

Figure B-1: Side-On Dewar, Shuttered

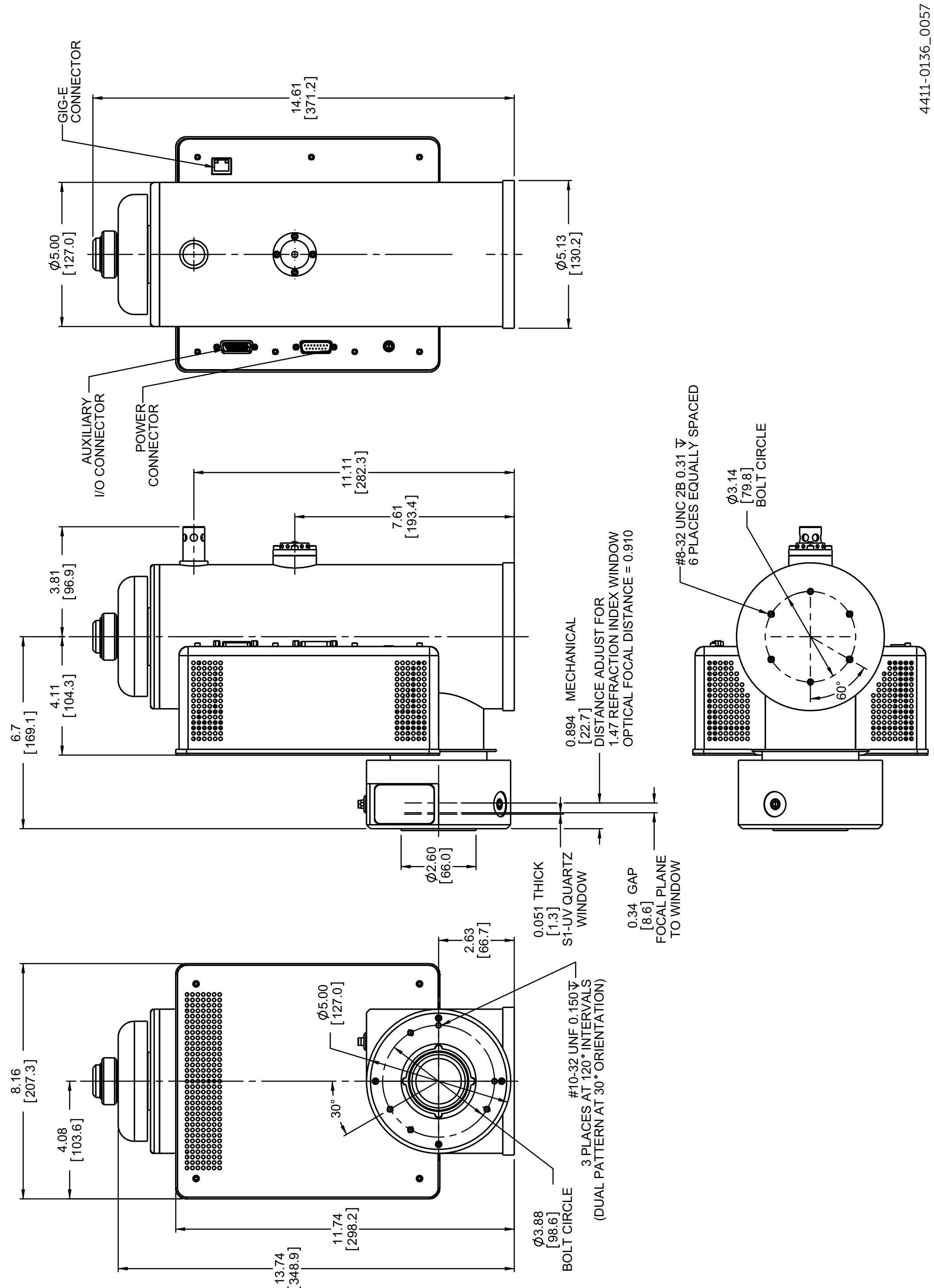
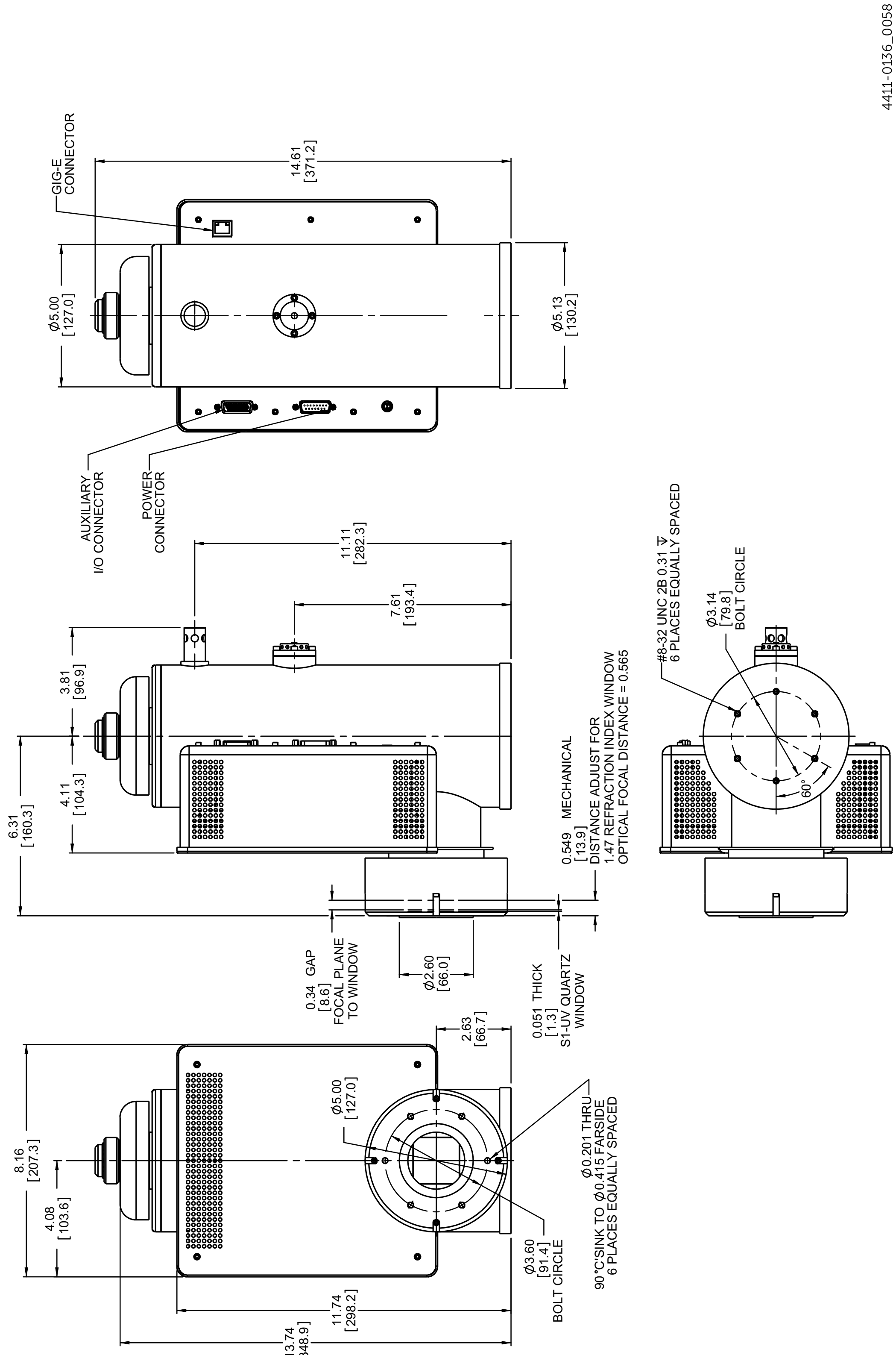


Figure B-2: Side-On Dewar, No Shutter



Appendix C: Spectrograph Adapters

Teledyne Princeton Instruments offers spectrograph adapters for PyLoN systems and Teledyne Acton Research spectrographs. The mounting instructions for these adapters are organized by spectrograph model, camera type, and adapter kit number (if available). Table C-1 cross-references these items with the page number for the appropriate instruction set,

Table C-1: Spectrograph Adapter Installation Information

Spectrograph	Camera Type	Adapter Kit #	Instructions begin on...
Teledyne Acton Research Series and IsoPlane 160	LN with shutter	7050-0100	page 116
Teledyne Acton Research Series and IsoPlane 160	LN without shutter		page 118
IsoPlane SCT-320	LN without shutter		page 120

C.1 Teledyne Acton Research Series and IsoPlane 160 Spectrographs with Shutter

Figure C-1 illustrates the installation of Spectrometer Adapter Kit 7050-0100 for Teledyne Princeton Instruments Series and IsoPlane SCT-160 spectrographs that are equipped with a shutter.

Figure C-1: Adapter for Teledyne Acton Research Series and IsoPlane 160 Spectrographs with Shutter

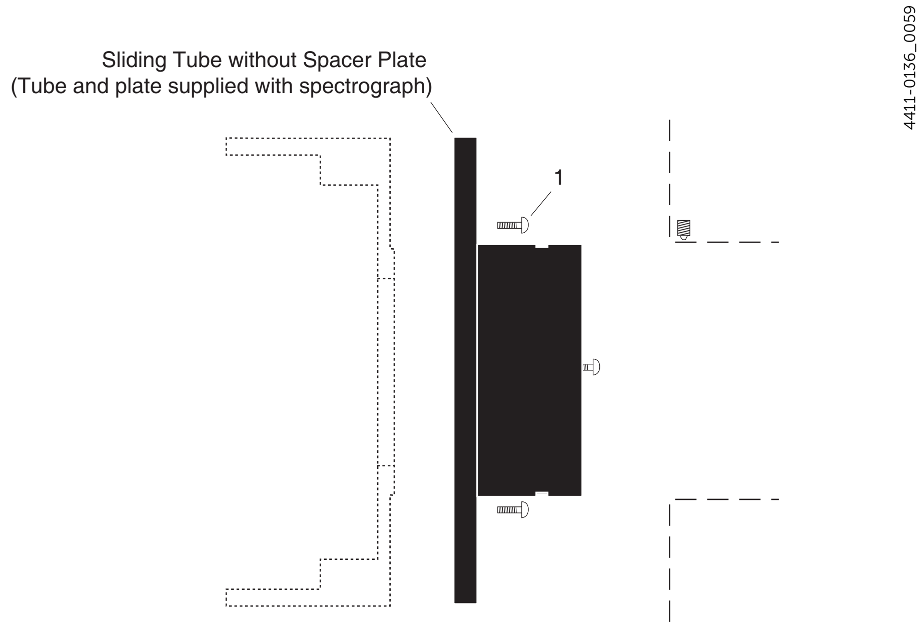


Table C-2 lists the required hardware to install this adapter.

Table C-2: Adapter Hardware: Teledyne Acton Research Series and IsoPlane SCT-160 Spectrographs with Shutter

Quantity	Part Number	Description
3	2827-0127	Screw, 10-32 x ¼, Button Head Allen Hex, Stainless Steel

C.1.1 Assembly Instructions

Perform the following procedure to install adapter kit 7050-0100 on a PyLoN when using a Teledyne Acton Research Series or IsoPlane SCT-160 spectrograph that is equipped with a shutter:

1. Verify that the shipping cover has been removed from the camera port on the spectrograph.
2. Loosen the set screws securing the sliding tube to the spectrograph.

> **CAUTION!**
>
> Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two set screws 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 set screws afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.

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 camera using the three (3) ¼" long button head screws included in the Spectrometer Kit (P/N: 7050-0100).

   Verify the baffle opening is aligned with the CCD array noting that the longest dimension is horizontal.
6. Rotate the sliding tube as you gently insert it into the spectrograph.
7. Secure the sliding tube using the set screws.

C.2 Teledyne Acton Research Series and IsoPlane SCT-160 Spectrographs without Shutter

Figure C-2 illustrates the installation of Spectrometer Adapter Kit 7050-0100 for Teledyne Princeton Instruments Series and IsoPlane SCT-160 spectrographs that are not equipped with a shutter.

Figure C-2: Adapter for Teledyne Acton Research Series and IsoPlane SCT-160 Spectrographs without Shutter

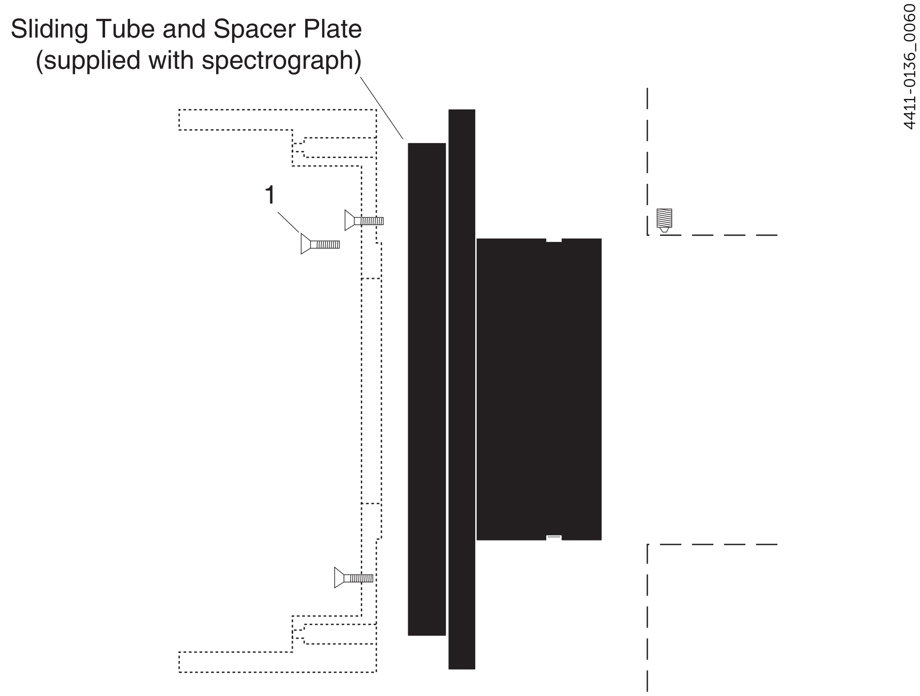


Table C-3 lists the required hardware to install this adapter.

Table C-3: Adapter Hardware: Teledyne Acton Research Series and IsoPlane SCT-160 Spectrographs without Shutter

Quantity	Part Number	Description
3	2826-0134	Screw, 10-32 x ¼, Flat Head Slot, Stainless Steel

C.2.1 Assembly Instructions

Perform the following procedure to install adapter kit 7050-0100 on a PyLoN when using a Teledyne Acton Research Series or IsoPlane SCT-160 spectrograph that is not equipped with a shutter:

1. Verify that the shipping cover has been removed from the camera port on the spectrograph.
2. Loosen the set screws securing the sliding tube to the spectrograph.

> ⚠ **CAUTION!**
>
> Adapter parts are machined to provide a tight fit. If you need to remove the sliding tube from the spectrograph, first loosen the two set screws 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 set screws afterwards to secure it. Forcing the tube into the spectrograph could permanently damage the tube and the spectrograph opening.

3. Rotate the sliding tube as you remove it from the spectrograph.
4. With a 3/32" ball head hex wrench, remove the four (4) socket screws securing the shroud to the front of the camera.
5. Carefully slide the shroud from the front of camera.
6. Attach the sliding tube with spacer to the shroud (i.e., illustrated by the dashed lines in Figure C-2,) using the flat head screws included in Spectrometer Kit 7050-0100.
7. Carefully slide the shroud back onto the front of the camera.
8. Align the baffle with the CCD array, and secure the shroud.
9. Rotate the sliding tube as you gently insert it into the spectrograph.
10. Secure the sliding tube with the set screws.

C.3 IsoPlane SCT-320 Spectrograph without Shutter

Figure C-3 illustrates the installation of Spectrometer Adapter Kit 7050-0100 for IsoPlane SCT-320 spectrographs that are not equipped with a shutter.

Figure C-3: Adapter for IsoPlane SCT-320 Spectrograph without Shutter

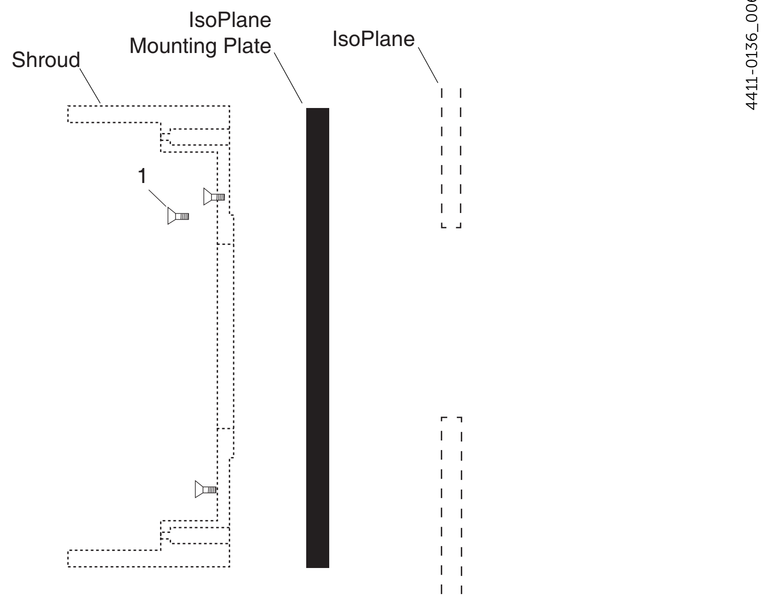


Table C-4 lists the required hardware to install this adapter.

Table C-4: Adapter Hardware: IsoPlane SCT-320 without Shutter

Quantity	Part Number	Description
3	2827-0134	Screw, 10-32 x ¼, Flat Head Slot, Stainless Steel
1	9000-469	Mounting Plate

C.3.1 Assembly Instructions

Perform the following procedure to install adapter kit 7050-0100 on a PyLoN when using an IsoPlane SCT-320 spectrograph that is not equipped with a shutter:

1. Verify the shipping cover has been removed from the camera port on the spectrograph.
2. Using a 9/64" hex wrench, loosen and remove the four (4) screws and washers securing the camera mounting plate to the IsoPlane SCT-320. Carefully remove the mounting plate.

   Retain the 4 screws and washers for use in step 7.
3. Using a 3/32" ball head hex wrench, remove the four (4) socket screws securing the shroud to the front of the camera.

   Retain these 4 socket screws for use in step 6.
4. Carefully slide the shroud from the front of camera.
5. Secure the shroud (i.e., illustrated by the dashed lines in Figure C-3,) to the mounting plate using the flat head screws included in Spectrometer Kit 7050-0100.
6. Carefully slide the shroud back onto the front of the camera and secure it using the four (4) screws that had been removed in step 3.
7. Secure the mounting plate to the IsoPlane SCT-320 using the four (4) screws and washers that had been removed in step 2.

NOTE:

Rotational alignment of the camera with the spectrograph optics is done by loosening the screws at the mounting plate corners, performing the alignment, and then tightening the screws. The holes are slotted to allow about 4° of rotation.

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Appendix D: WinX/LightField Cross Reference

This appendix provides cross reference information for terminology used within the WinX and LightField application software packages.

D.1 WinX-to-LightField Terminology

Refer to Table D-1 for a list of WinX terms and their corresponding LightField terms.

Table D-1: WinX-to-LightField Cross Reference (Sheet 1 of 2)

WinX Term	LightField Term
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
Disabled Closed (Shutter)	Always Closed (Shutter)
Disabled Open (Shutter)	Always Open (Shutter)
Dual Trigger Mode	Shift Per Trigger
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
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

Table D-1: WinX-to-LightField Cross Reference (Sheet 2 of 2)

WinX Term	LightField Term
Logic Out: Shutter	Output Signal: Shutter Open
Minimum Block Size	Final Section Height
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
Shutter Open Compensation Time	Opening Delay
Single Trigger Mode (DIF)	Readout Per Trigger
Skip Serial Register Clean (deselected)	Clean Serial Register
Target Temperature	Temperature Setpoint
Timing Mode	Trigger Response

D.2 LightField to WinX

Refer to Table D-2 for a list of LightField terms and their corresponding WinX terms.

Table D-2: LightField-to-WinX Cross Reference (Sheet 1 of 2)

LightField Term	WinX Term
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
No Response	Free Run
Normal (Shutter)	Normal Shutter
Number of Clean Cycles	Number of Cleans
Open Before Trigger (Shutter)	PreOpen (Shutter)
Opening Delay	Shutter Open Compensation Time
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
Output Signal: Not Reading Out	Logic Out: Not Scan
Output Signal: Shutter Open	Logic Out: Shutter

Table D-2: LightField-to-WinX Cross Reference (Sheet 2 of 2)

LightField Term	WinX Term
Preview	Focus
Quality	Readout Port
Readout Per Trigger	External Sync
Readout Per Trigger (DIF)	Single Trigger (DIF)
Sensor Readout Region expander functions	Easy Bin
Shift Per Trigger (DIF)	Dual Trigger Mode (DIF)
Shutter Mode	Shutter Control
Speed	ADC Rate
Temperature Setpoint	Target Temperature
Trigger Determined By	Edge Trigger
Trigger Response	Timing Mode

Warranty and Service

Limited Warranty

Teledyne 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

Teledyne 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, Teledyne 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 Teledyne 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 Teledyne Princeton Instruments authorized representative/distributor for repair information and assistance, or visit our technical support page at www.princetoninstruments.com.

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

Teledyne 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, Teledyne 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 Teledyne Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Teledyne Princeton Instruments. International customers should contact their local Teledyne Princeton Instruments representative/distributor for repair information and assistance or visit our technical support page at www.princetoninstruments.com.

XP Vacuum Chamber Limited Lifetime Warranty

Teledyne 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 Teledyne 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

Teledyne 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

Teledyne 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. Teledyne 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. *Refer to 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

Teledyne 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. *Refer to 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

Teledyne 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. Teledyne 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 CDROM from our factory for an incidental shipping and handling charge. *Refer to Item 12 in Your Responsibility of this warranty 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 Teledyne 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 Teledyne Princeton Instruments technical support staff or our authorized service representative. *Refer to Item 12 in Your Responsibility of this warranty 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 Teledyne Princeton Instruments.
2. You must notify the Teledyne 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 Teledyne 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 Teledyne 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 Teledyne Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Teledyne 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 Teledyne 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 Teledyne Princeton Instruments factory or a Teledyne 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 Teledyne 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 Teledyne Princeton Instruments factory of purchase, contact your authorized Teledyne Princeton Instruments representative or reseller, or visit our technical support page at www.princetoninstruments.com.

Contact Information

Teledyne Princeton Instruments' manufacturing facility for this product is located at the following address:

Teledyne 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

Refer to http://www.princetoninstruments.com/support for complete support and contact information, including:

- Up-to-date addresses and telephone numbers;
- Software downloads;
- Product manuals;
- Support topics for Teledyne Princeton Instruments' product lines.

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www.princetoninstruments.com

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