TELEDYNE PRINCETON INSTRUMENTS
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Part of the Teledyne Imaging Group

PyLoN®-IR Camera System

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www.princetoninstruments.com

Revision History

Issue	Date	List of Changes
Issue 7	May 10, 2019	Issue 7of this document incorporates the following changes: • Rebranded as Teledyne Princeton Instruments.
Issue 6	April 20, 2016	Issue 6 of this document incorporates the following changes: • Removed the Declaration of Conformity.
Issue 5	October 28, 2015	Issue 5 of this document incorporates the following changes: • Updated the Declaration of Conformity; • Updated Appendix C, Spectrograph Adapters, to reflect the availability of only one adapter; • Added Appendix D, Calibration Charts. • Corrected the following procedures in Chapter 5, LightField First Light Procedure: • Section 5.4, Rotational Alignment and Focus; • Added Section A.7, Quantum Efficiency; • Converted to FrameMaker Template.
Issue 4	February 26, 2014	Issue 4 of this document incorporates the following changes: • Updated step 5 of the procedure to fill the dewar on page 37 (removed outdated information); • Corrected the default detector temperature on page 51 (changed from -120° to -100°.)
Issue 3	July 9, 2013	Issue 3 of this document incorporates the following changes: • Updated the Declaration of Conformity; • Added nominal DC output voltages to the Power Supply specifications.
Issue 2	May 30, 2013	Issue 2 of this document incorporates the following changes: • Updated Grounding and Safety warnings; • Added separate Power Supply section to Appendix A, Technical Specifications.
Issue 1	April 1, 2013	This is the initial release of this document

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Chapter 1: About this Document

Thank you for purchasing a PyLoN®-IR camera system from Teledyne Princeton Instruments. The system has been thoroughly tested to meet Teledyne Princeton Instruments' exacting standards and to meet the demanding requirements of many low light level imaging applications.

This manual provides users with information necessary to install a PyLoN-IR camera and place it in operation. Topics include a detailed description of the PyLoN-IR camera family as well as the installation, applications, cleaning, and specifications of the camera system.

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 being collected using the PyLoN-IR camera system.

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

Please read this manual carefully before attempting to operate the camera. Doing so will help minimize the learning curve and optimize the many features of this camera to suit all research needs.

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-IR camera system.

Table 1-1: Related Documentation

Document Number	Document Title
4411-0125	LightField 4 User's Manual
4411-0147	LightField 5 Installation Manual
4411-0048	WinSpec 2.6 Spectroscopy Software User Manual

Current issues of Teledyne Princeton Instruments' manuals are available for downloaded from:

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

Current issues of Teledyne Acton Research manuals are available for downloaded from:

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

1.3 Document Organization

This manual includes the following chapters and appendices:

- Chapter 1, About this Document

  This chapter provides information about the structure of this manual, and documents environmental, storage, and cleaning requirements.
- Chapter 2, PyLoN-IR Camera System

  This chapter briefly describes the PyLoN-IR family of detectors and provides descriptions of each system component.
- Chapter 3, Installation

  Cross-references system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.
- Chapter 4, Initial Setup and Operation

  Provides detailed directions for mounting the detector to a spectrometer and for interconnecting the system components.
- Chapter 5, LightField First Light Procedure

  This chapter provides a step-by-step procedure for placing a spectroscopy system in operation for the first time when using Teledyne Princeton Instruments' LightField 64-bit data acquisition software.
- Chapter 6, WinSpec/32 First Light Procedure

  This chapter provides a step-by-step procedure for placing a spectroscopy system in operation for the first time when using Teledyne Princeton Instruments' WinSpec/32 data acquisition software.
- Chapter 7, Exposure and Signal

  This chapter discusses the various factors that affect the signal acquired on the array, including array architecture, exposure time, temperature, and saturation.
- Chapter 8, Experiment Synchronization

  Discusses standard timing modes (Free Run, External Sync, and Continuous Cleans), Fast and Safe triggering modes, and TTL control.
- Chapter 9, Troubleshooting

  Provides courses of action to take if you should have problems with your system.
- Appendix A, Technical Specifications

  Includes computer, controller and detector specifications.
- Appendix B, Outline Drawings

  Includes outline drawings of the PyLoN-IR detector and its power supply.
- Appendix C, Spectrograph Adapters

  Provides mounting instructions for the spectrograph adapters available for PyLoN-IR detectors.
- Appendix D, Calibration Charts
- Provides the HG and Ne-Ar Calibration Spectra for use with the PyLoN-IR.
- Appendix E, WinSpec/32/LightField Cross Reference

  Provides two alphabetically sorted tables (WinSpec/32 to LightField and LightField to WinSpec/32) that cross reference terms used in the two applications.
- Warranty and Service

  Provides the Teledyne Princeton Instruments warranty and customer support contact information.

1.4 Conventions Used in this Manual

The following conventions are used throughout this manual:

- WinSpec/32 and LightField® typically use different terms for the same functions or parameters. Unless a topic is specifically for WinSpec/32 or LightField, the following conventions are used:
  - Curly brackets { } are used to denote a LightField term or location.
  - When information applies to both WinSpec/32 and LightField, the WinSpec/32 term will be listed first, followed by the LightField term surrounded by curly brackets.

    For example:

    Continuous Cleans {Clean Until Trigger}
  - When a location for setting a parameter is mentioned, the WinSpec/32 location will be listed first, followed by the LightField location surrounded by curly brackets.

    For example:

    Exposure Time is configured on the Experiment Setup ► Main tab {Common Acquisition Settings expander}.

1.5 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-IR 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 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.

1.5.1 Safety Related Symbols Used in this Manual

CAUTION!

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

WARNING! RISK OF ELECTRIC SHOCK!

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

1.6 Precautions

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

- The array is very sensitive to static electricity. Touching the array can destroy it. Operations requiring contact with the device can only be performed at the factory.
- If you are using high-voltage equipment (such as an arc lamp) with your detector system, be sure to turn the detector power ON LAST and turn the detector power OFF FIRST.
- 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 detector. Ignore the LED status if there is no shutter.

NOTE:

The “SHUTTER FAULT” LED also lights when an external shutter is disabled closed.

- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The array can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Do not block air vents on the detector. Preventing the free flow of air overheats the detector and may damage it.

1.6.1 Detector

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.

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).

If LN-cooled detectors are operated under high humidity conditions, ice buildup could occur around the pressure relief vent valve ports and prevent them from operating properly.

1.6.2 Detector Window

WARNING!

Never remove the detector’s front window; ice will form immediately, destroying the array. Operations requiring contact with the device can only be performed at the factory.

Never operate the detector cooled without proper evacuation. This could destroy the array!

This window maintains the vacuum in the detector and, for LN-cooled detectors, it maintains the vacuum in the Dewar. The window is made of the highest quality quartz available.

1.6.3 External Shutter

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

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Chapter 2: PyLoN-IR Camera System

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

Figure 2-1: Standard PyLoN-IR System Components

Standard items include:

- PyLoN-IR Detector with Standard Upright Dewar;
- Power Supply and Cable;
- Ethernet Card;
- Gigabit Ethernet cable;
- Aux I/O Cable;
- Certificate of Performance;
- PyLoN-IR User Manual.

Optional items include:

- External Shutter;
- Application software.
- Data Acquisition Software:
  - — LightField;
  - — WinSpec/32.

2.1 Standard Equipment

This section provides general information about standard equipment included in a PyLoN-IR system.

REFERENCES:

Refer to Appendix A, Technical Specifications, for detailed technical information, specifications, and requirements.

2.1.1 PyLoN-IR Detector with Standard, Upright Dewar

The PyLoN-IR, shown in Figure 2-2, uses a 1024-element linear InGaAs photodiode array (PDA) for near infrared (NIR) spectroscopy applications. InGaAs provides excellent response in the NIR from 0.8 μm to 1.7 μm or from 1 μm to 2.2 μm, depending on the PyLoN-IR detector. This 16-bit detector offers outstanding sensitivity for applications such as NIR Raman and emission, plus high dynamic range for NIR transmission, reflectance, and absorbance. Its liquid nitrogen-cooling is ideal for low light level applications requiring long integration times.

Figure 2-2: Typical PyLoN-IR Detector

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The PDA is a third generation, solid state, image device capable of performing these three essential functions: transducing photons to electrons, integrating and storing, and reading. The array is rugged, compact, and resilient to mechanical shocks, direct exposure to high light levels, and magnetic and RF radiation. PDAs are particularly suited to applications where accuracy, precision, high dynamic range, low noise and high geometric stability are most important. The arrays are, to a great degree, lag and blooming free.

This section provides detailed information about the PyLoN-IR detector.

2.1.1.1 Linear Photodiode Array

The 1024-element linear InGaAs photodiode arrays (PDA) with silicon multiplexer readout electronics provide excellent response in the Near InfraRed (NIR) from 0.8 μm to 1.7 μm or from 1 μm to 2.2 μm, depending on the detector model. This 16-bit detector offers outstanding sensitivity for applications such as NIR Raman and emission, plus high dynamic range for NIR transmission, reflectance, and absorbance.

2.1.1.2 Window

The PyLoN-IR window is composed of SI-UV fused silica quartz.

2.1.1.3 Rear-Panel Connectors

Figure 2-3 illustrates the rear-panel connectors on a PyLoN-IR detector.

Figure 2-3: PyLoN-IR Rear-Panel Connectors

Refer to Table 2-1 for information about each rear-panel connector.

Table 2-1: PyLoN-IR Rear-Panel Connectors

Label	Description
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, $+16V_{DC}$, $-16V_{DC}$, $+5.9V_{DC}$, $-5.9V_{DC}$, $+4.3V_{DC}$ power supplies. Also used for the Shutter High Voltage Control signal.
Shutter	LEMO® connector for driving an external shutter. Stop data acquisition and turn off the power supply before connecting to or disconnecting from this connector.
Gig-E	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.

2.1.1.4 Upright Dewar

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

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 LN 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.
3. An LN-cooled detector must never be tilted more than 30° from vertical, unless the 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.

Optional End-on and All-directional Dewar inserts are available. Contact Teledyne Princeton Instruments for more information.

2.1.2 Power Supply

The PyLoN-IR detector receives its power from an external power supply, which in turn plugs into an external source of AC power.

Figure 2-4 illustrates a typical PyLoN-IR power supply.

Figure 2-4: Typical PyLoN-IR Power Supply

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

2.1.3 Cables

Table 2-2 provides information about cables included with a standard PyLoN-IR Camera System.

Table 2-2: Standard PyLoN-IR Camera System Cables

Cable	Part Number	Description/Purpose	Length
Ethernet	6050-0621	Cat 5e/6 Ethernet cable. Connects the PyLoN-IR camera to the host computer. The detector and the computer may be more than 50 meters apart. Contact the factory to order longer cables. 	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. 	
Power	6050-0673	Connects the PyLoN-IR detector to the power supply. 	3 m [9.8 ft]

2.1.4 PyLoN-IR System User Manual

The PyLoN-IR System User Manual describes how to install, configure, and use a PyLoN-IR camera and its components.

2.1.5 Certificate of Performance

Each PyLoN-IR 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-IR 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.

2.2 Accessories and Optional Equipment

Teledyne Princeton Instruments offers a number of optional accessories that are compatible with PyLoN-IR. This section provides information about each of them. For complete ordering information, contact Teledyne Princeton Instruments.

2.2.1 Dewar Inserts

Optional End-on and All-directional Dewar inserts are available for use with the PyLoN-IR camera system.

2.2.2 Spectrometer Support and Accessories

Teledyne Princeton Instruments offers extensive support for spectrograph integration, including fiberoptic accessories, lenses, lens mounts, f# matchers, and spectrograph flanges. The PyLoN-IR detector can be coupled with the entire line of Teledyne Acton Research spectrographs, as well as the IsoPlane spectrograph family, providing fully integrated instruments that offer automated software control of both spectrograph and detector.

Refer to Appendix C, Spectrograph Adapters, on page 97, or the quick start instruction shipped with the spectroscopy system, for information about mounting the PyLoN-IR to a compatible spectrograph.

2.2.3 Application Software

Teledyne Princeton Instruments offers a number of data acquisition software packages for use with PyLoN-IR camera systems, including:

- LightField®
  The PyLoN-IR 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.
  A PDF version of the LightField User Manual is provided on the installation CD. The manual describes how to install and use the LightField application program. Additional information is available in the program's online help.
- 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 detectors and spectrographs. This third party software can be purchased from Teledyne Princeton Instruments.

- WinSpec/32

  The PyLoN-IR 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-IR camera and even enhance it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

  The WinSpec/32 User Manual describes how to install and use the application program. A PDF version of this manual is provided on the installation CD. Additional information is available in the program's online help.

- PVCAM®

  A standard software interface for cooled PDA, FPA, and CCD detectors from Teledyne Princeton Instruments. It is a library of functions that can be used to control and acquire data from the detector 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 detector 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.

2.3 Minimum Host Computer Specifications

Host Computer specifications vary based on the data acquisition software being used. This section provides minimum host computer specifications by software package.

NOTES:

1. Computers and operating systems undergo frequent revisions. The following information is intended to provide an approximate indication of the computer requirements. Contact the factory to confirm specific requirements.
2. The specifications listed are the MINIMUM required for a PyLoN-IR camera. A faster computer with 2 GB (or more) RAM and a fast hard drive (e.g., 10,000 rpm,) will greatly improve system performance during live mode operations.

2.3.1 LightField Installations

When running LightField data acquisition software, the host computer must meet, or exceed, the following specifications:

- 64-bit Operating System;
  - Windows Vista®;
  - Windows® 7;
- 2 GHz Pentium® 4 (minimum;)
- 1 GB RAM (minimum;)
- CD-ROM drive;
- At least one unused PCI card slot (32-bit) (PCI 2.3 compliant 32-bit 33/66 MHz bus;)
- Super VGA monitor and graphics card;
  Must support a minimum of 65535 colors with at least 128 Mbyte of memory.

  NOTE:
  Memory requirement is dependent on desired display resolution.

- 10,000 RPM (recommended) hard disk with a minimum of 1 GB available space.
  A complete LightField installation requires approximately 50 MB of space. The remaining space is required for data storage, and is dependent on the number and size of images/spectra collected.

  NOTE:
  Disk level compression programs are not recommended.

- Mouse or other pointing device.

2.3.2 WinSpec/32 Installations

When running WinSpec/32 data acquisition software, the host computer must meet, or exceed, the following specifications:

- 32-bit Operating System;
  - Windows® XP (SP3 or later;)
  - Windows Vista®; or
  - Windows® 7;
- 2 GHz Pentium® 4 (minimum;)
- 2 GB RAM (minimum;)
- CD-ROM drive;
- At least one unused PCI card slot (32-bit) (PCI 2.3 compliant 32-bit 33/66 MHz bus;)
- Super VGA monitor and graphics card;
  Must support a minimum of 65535 colors with at least 128 Mbyte of memory.

  NOTE:
  Memory requirement is dependent on desired display resolution.

- 10,000 RPM (recommended) hard disk with a minimum of 1 GB available space.
  A complete WinSpec/32 installation requires approximately 50 MB of space. The remaining space is required for data storage, and is dependent on the number and size of images/spectra collected.

  NOTE:
  Disk level compression programs are not recommended.

- Mouse or other pointing device.

2.4 Care and Cleaning of a PyLoN-IR System

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.

2.4.1 Detector

Although there is no periodic maintenance that *must* be performed on the PyLoN-IR detector, 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.

2.4.2 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.

2.5 Repairs

Save the original packing materials. Any repairs must be done by Teledyne Princeton Instruments. Should the system need repair, contact Teledyne Princeton Instruments customer service for instructions. Refer to Contact Information on page 110 for complete information.

Use the original packing materials whenever shipping the system or system components.

Chapter 3: Installation

Figure 3-1 and Figure 3-2 are high-level block diagrams of typical system configurations.

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

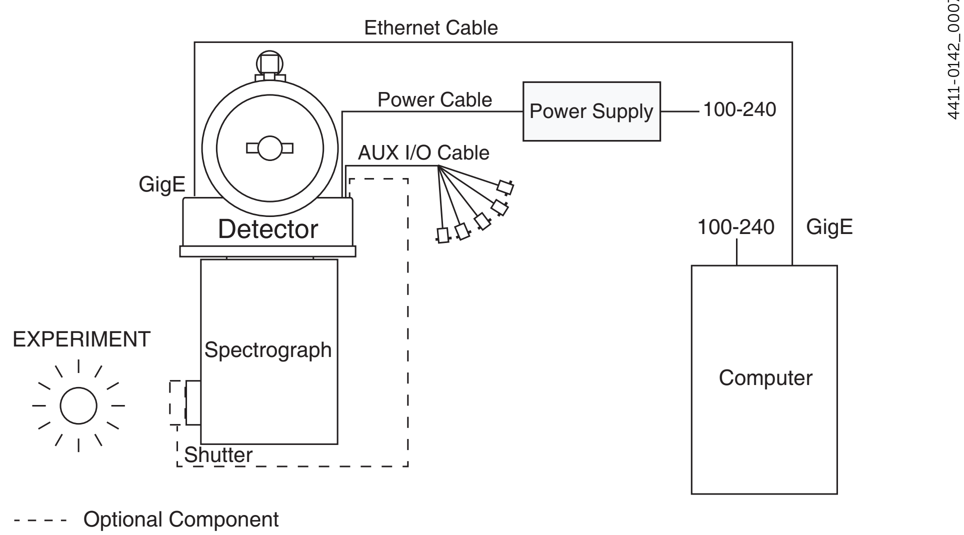

Figure 3-2: Block Diagram: PyLoN-IR with IsoPlane Spectrograph

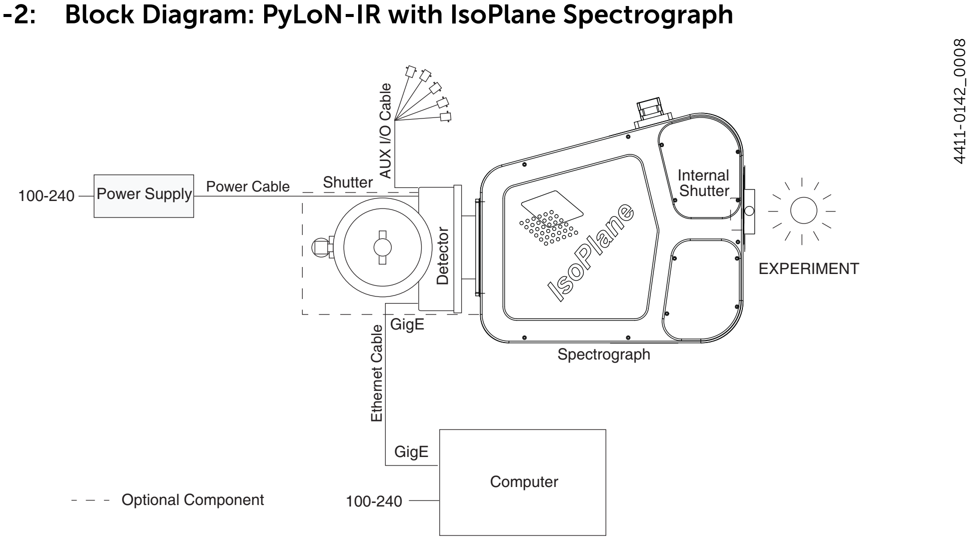

Table 3-1 lists the recommended sequence of steps required to install a PyLoN-IR system and prepare to gather data.Where provided, refer to the references with each step for additional information.

Table 3-1: PyLoN-IR System Installation Procedure (Sheet 1 of 2)

Action	For additional information, 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 29
2. Verify that all system components have been received.	Section 4.1.1, Check the Equipment and Parts Inventory, on page 29
3. If the components show no sign of damage, verify that the appropriate power cord has been supplied with the power supply.	—
4. 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-IR system. WinSpec/32: If the Ethernet adapter card provided with the system is not already installed in the host computer, install it.	Refer to the manufacturer supplied installation instructions.
5. If the application software has not already been installed on the host computer, install it.	Section 4.2.1, Install LightField, on page 30; Section 4.2.2, Install WinSpec/32, on page 31
6. Mount the detector to the spectrograph.	Section 4.3, Mount to a Spectrograph, on page 32
7. With the power supply disconnected from the detector, connect one end of the Ethernet cable to the GigE connector on the rear of the PyLoN-IR and the other end to the Ethernet port on the host computer.	—
8. Connect the power supply to the PyLoN-IR.	—
9. Turn the PyLoN-IR power supply ON.	—
10. Turn on the computer and launch either LightField or WinSpec.	LightField User Manual[a] WinSpec/32 User Manual[a]
11. Enter the hardware and experiment setup information.	LightField User Manual[a] WinSpec/32 User Manual[a]
12. Set the target array temperature.	Section 7.4.1, Array Temperature Control, on page 59
13. Fill the Dewar.	Section 4.6, Fill the Dewar, on page 36

Table 3-1: PyLoN-IR System Installation Procedure (Sheet 2 of 2)

Action	For additional information, refer to...
14. When the system reaches temperature lock, wait an additional 30 minutes before acquiring data in focus mode.	
15. Adjust the focus for the best image or spectral lines.	
• When using LightField, use the Align Spectrometer function.	Section 5.4, Rotational Alignment and Focus, on page 44
• When using WinSpec/32, use the Focus Helper function.	Section 6.6, Rotational Alignment and Focusing on page 53

a. Refer to Table 1-1 on page 9 for document number information.

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Chapter 4: Initial Setup and Operation

NOTE:

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

This chapter provides general information and procedures for the initial set up and operation of a PyLoN-IR system for both imaging and spectroscopic applications.

4.1 Unpack the System

When unpacking the system, examine all components for possible signs of shipping damage. If there are any, notify Teledyne Princeton Instruments and file a claim with the carrier. If damage is not apparent but detector or controller specifications cannot be achieved, internal damage may have occurred in shipment. Please save the original packing materials so you can safely ship the detector system to another location or return it to Teledyne Princeton Instruments for repairs if necessary.

4.1.1 Check the Equipment and Parts Inventory

Verify that all equipment and parts required to set up the PyLoN-IR system have been received.

A complete, standard system consists of:

- Detector and Power Supply;
- Host Computer;

  Can be purchased from Teledyne Princeton Instruments or user-supplied. Refer to Section 2.3, Minimum Host Computer Specifications, for complete information.

  For enhanced performance, a fast hard drive (10,000 rpm) and 2 GB RAM is recommended.
- Operating System:
  - LightField: Windows Vista (64-bit) or Windows 7 (64-bit);
  - WinSpec/32: Windows XP (32-bit, SP3 or later) or Vista (32-bit);
- Interface Card;

  An Intel® PRO/1000 card is supplied with the system.
- GigE cable;

  DB9-to-DB9 cable (6050-0148-CE) is standard.
- PyLoN-IR System User Manual.

Optional items that may have been purchased and are included in the shipment are:

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

4.2 Install Data Acquisition Software

This section provides installation procedures for LightField and WinSpec/32 data acquisition software.

4.2.1 Install LightField

Perform the following procedure to install LightField on the host computer:

NOTE:

Install the GigE Adapter card BEFORE installing the LightField application software.

1. Verify that the operating system on the desired host computer is either Windows Vista (64-bit) or Windows 7 (64-bit).
2. Confirm that the Pro 1000 interface card has been installed.
3. Verify that the host computer is connected to the Internet. An internet connection may be required for product activation.
4. Insert the LightField Installation CD into the CD drive on the host computer, and follow the on-screen prompts. Figure 4-1 illustrates a typical InstallShield Wizard dialog.

Figure 4-1: Typical LightField InstallShield Wizard Dialog

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5. After the installation has been completed, reboot the host computer.
6. Connect the PyLoN-IR system components to the host computer and apply power.
7. Launch LightField and activate it according to on-screen instructions.

REFERENCES:

For additional information, refer to Chapter 5, LightField First Light Procedure, on page 41.

8. Begin experiment configuration.

4.2.2 Install WinSpec/32

This section provides the installation procedure for WinSpec/32 application software.

NOTES:

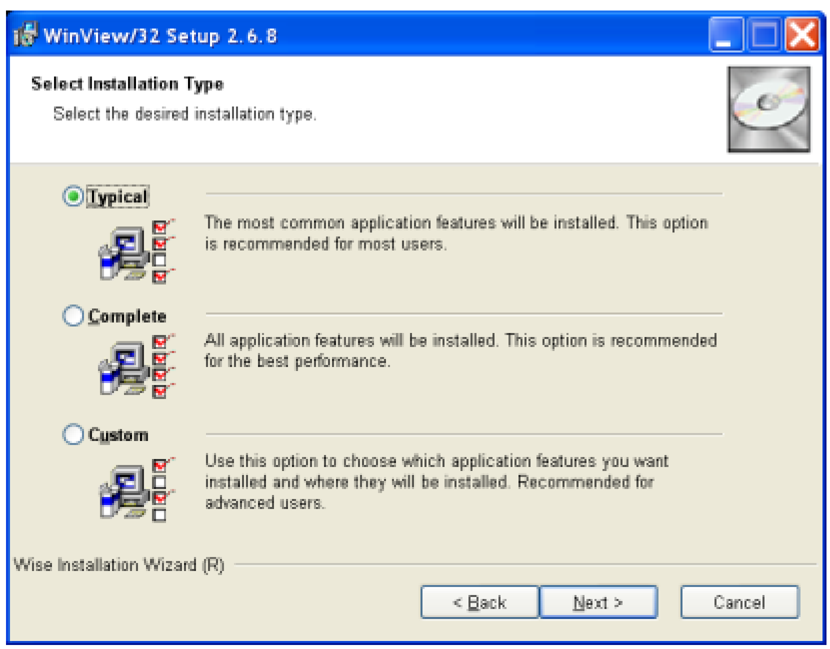
1. Install the GigE Adapter card BEFORE installing the WinSpec/32 application software.
2. The interface cable should remain disconnected from the camera until after WinSpec/32 (version 2.5.25 or higher) has been successfully installed.

Perform the following procedure to install WinSpec/32 on the host computer:

1. Insert the WinSpec/32 software installation CD into the CD drive on the host computer. The installation program will automatically launch.
2. When the Select Installation Type dialog is displayed, select the desired type of installation.
   - Typical installs all required drivers and the most commonly installed program files;
   - Complete installs all available application drivers and features;
   - Custom is used to select specific features and drivers for installation, as well as specifying a custom installation directory. This is only recommended for use by advanced users.

   Figure 4-2 illustrates a typical WinSpec/32 Setup dialog.

Figure 4-2: Typical WinView/32 Setup Dialog



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3. Click Next > to continue with the installation, and continue to follow on-screen prompts.
4. Once the installation has been completed, connect the camera to the host computer and turn on the camera's power supply.
5. Reboot the host computer.
   Windows will automatically detect the newly-installed GigE card.

REFERENCES:

For additional information, refer to Chapter 6, WinSpec/32 First Light Procedure, on page 49.

4.3 Mount to a Spectrograph

Allow a minimum of one inch clearance for side and rear air vents. When the detector is placed inside an enclosure, > 30 cfm air circulation and heat dissipation of 50 W is required.

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

Refer to the adapter mounting instructions in Appendix C, Spectrograph Adapters, on page 97, or the quick-start instructions that may have been included with the system.

WARNING!

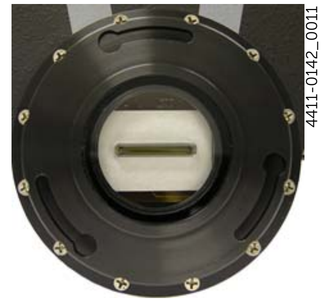
An LN-cooled detector must never be tilted more than 30° from vertical unless the "all-directional" Dewar option has been purchased. If mounting the Dewar to the system requires the 30° limit be exceeded, the wrong type of Dewar may be in use. Contact the factory before proceeding. Refer to Contact Information on page 110 for complete information.

4.3.1 Optical Center of the Array

LN-cooled detectors shrink when the Dewar is filled with LN and the detector cools down to operating temperature. For side-on Dewars, the optical center of the array 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 detector cools.

The PyLoN-IR is designed so the optical center of an array is offset at room temperature. When a detector cools to operating temperature, the optical center of the array is at the center of the nose.

4.3.2 Array Orientation



All users with rectangular arrays must first determine the correct orientation of the detector. All detectors must be mounted in the correct orientation to take advantage of the many hardware and software features. The detector should be mounted so that the short axis of the array is parallel to the entrance slit. The long axis will therefore correspond to the wavelength axis of the spectrum, for maximum resolution.

The simplest way to determine the long and short axes of an array is to visually inspect the faceplate. The faceplate cutout closely corresponds to the dimensions of the underlying array, which will itself be visible through the window.

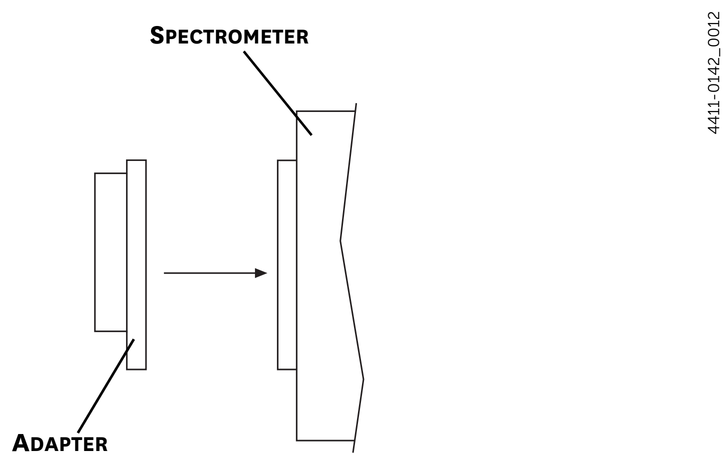
4.4 Install an External Shutter

PyLoN-IR detectors are not equipped with internal shutters. However, a Teledyne Princeton Instruments 25 mm external shutter, typically installed at the entrance slit of a spectrograph, is available for purchase.

Perform the following procedure to install and setup a Teledyne Princeton Instruments' 25 mm External Shutter:

1. Verify that the detector'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 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-IR's electronics box.
4. After turning on the detector's power supply and launching WinSpec/32, navigate to the Hardware Setup ► Controller/Camera tab and select Custom as the Shutter Type. The time it takes the shutter to completely close is approximately 8 ms.

NOTE:

Configuring the shutter compensation time will slow the readout rate.

4.5 Configure Default Parameters

Once the hardware has been installed and setup, configure basic default parameters for the data acquisition software being used. If necessary, refer to the Software User's Manual for complete information.

4.5.1 LightField

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

1. Verify the PyLoN-IR and spectrograph, if applicable, are connected to the host computer, and that power supplies for the detector and spectrograph 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 area in the Experiment workspace.
4. Once an icon has been dragged into the Experiment Devices area, the appropriate expanders and default configuration values are loaded into the Experiment Settings stack on the left hand side of the window.

NOTE:

Refer to Chapter 5, LightField First Light Procedure, on page 41 for step-by-step procedures and complete information about basic system operation.

4.5.2 WinSpec/32

Perform the following procedure to configure default system parameters within WinSpec/32:

1. Verify the detector is connected to the host computer and that the detector's power supply is turned on.

   The PyLoN-IR camera must be powered on before launching WinSpec/32 to ensure communication between the camera and the host computer. If WinSpec/32 has been launched and PyLoN-IR has not been powered on, many functions will be disabled, and only previously acquired and stored data can be retrieved and reviewed.
2. Launch the WinSpec/32 application software.

   The Camera Detection Wizard will automatically run if this is the first time a Teledyne Princeton Instruments WinSpec/32 application and supported detector have been installed.

   Otherwise, when installing a new detector type, click on the Launch Camera Detection Wizard... button on the Controller/CCD tab to start the wizard.

3. When the Welcome dialog is displayed, verify the checkbox is unselected and click Next >. See Figure 4-4.

Figure 4-4: Typical WinSpec Camera Detection Wizard

4. Continue following on-screen prompts and instructions to complete the initial hardware setup. The wizard enters default parameters on the Hardware Setup dialog tabs and provides an opportunity to acquire a test image to confirm proper system operation.

NOTE:

Refer to Chapter 6, WinSpec/32 First Light Procedure, on page 49 for step-by-step procedures and complete information about basic system operation.

4.6 Fill the Dewar

PyLoN-IR detectors use liquid nitrogen to reduce the temperature of the array. The liquid nitrogen is stored in a Dewar that is enclosed in a vacuum jacket for minimal external thermal losses.

WARNINGS!

1. Wear protective equipment. Minimal contact with Liquid Nitrogen may cause severe injury to eyes and skin. Avoid contact with the splashing that will invariably accompany pouring Liquid Nitrogen into a room temperature Dewar.
2. Always be careful when removing the Dewar filler cap when Liquid Nitrogen is present in the Dewar. Pressure due to nitrogen gas can cause the cap to fly off once the retaining nut has been loosened, possibly spraying liquid Liquid Nitrogen, which can cause severe injury.

CAUTION!

Because of low operating temperatures, cryogenically-cooled detectors must always be connected to a powered ON detector. If the detector power is turned off when liquid nitrogen remains in the Dewar, the array temperature will drop below the array's normal operating temperature of -100°C. The array will not work properly until power has been restored and the array has warmed back up to -100°C.

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 detector monitors the array temperature. The array temperature can be programmed from 50°C to -100°C, but the pixel gain and offset corrections will be best when the camera is at its default temperature of -100°C.

Perform the following procedure to fill the dewar with liquid nitrogen:

1. Loosen the retaining nut a few turns, then remove the LN Dewar Port Cap by pulling it straight out from the dewar.

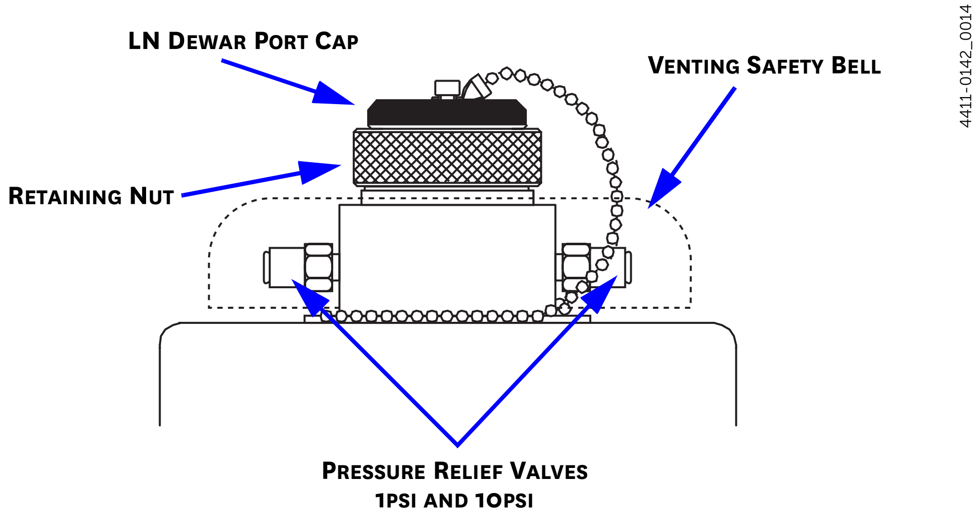
   CAUTION!

   It is strongly recommended that a liquid nitrogen transfer dewar with pouring spout be used to transfer liquid nitrogen from the storage tank to the detector.

   When using a funnel, always slide a thin venting tube through the funnel and down into the dewar to reduce splashing due to boiling liquid nitrogen.

   See Figure 4-5.

Figure 4-5: Dewar Ports and Valves



2. Pour approximately 100 ml of liquid nitrogen into the dewar.
3. Wait for approximately 5-10 minutes until a geyser-like vapor burst from the dewar's opening is observed. This burst is normal and indicates that a thermal equilibrium between the liquid nitrogen and the dewar container's surfaces has been achieved.
4. If necessary, pour in additional liquid nitrogen to fill up the dewar. The capacity for the standard dewar is approximately 1.7 liters.

> **NOTE:**
> The liquid nitrogen level in the dewar can be tested by briefly inserting a straight piece of wire (i.e., a cryogenic "dip stick,") into the dewar and then removing it. The liquid nitrogen level is indicated by the condensation on the wire.

5. Once the dewar has been filled, replace the filler cap and hand-tighten the retaining nut until the nut feels snug.

> **WARNING!**
> Ice buildup may occur at the pressure relief valve ports if the detector is being operated under high humidity conditions. Ice buildup could prevent the valves from venting properly. Because the venting safety bell covers the valves, this condition would not be readily apparent.

6. Set the target temperature within WinSpec/LightField. Once the target temperature has been reached, the software will indicate that the Current Temperature has Locked.

NOTES:

1. A liquid nitrogen cooled array typically cools to -100°C in under 2 hours.
2. 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.
3. Within WinSpec/32, the Detector Temperature dialog does not display temperature information during data acquisition.

CAUTION!

The pressure relief valve underneath the protective covering will occasionally emit a plume of nitrogen gas and mist. Continuous hissing indicates that the vacuum in the dewar jacket is probably inadequate. In this case, first remove all liquid nitrogen 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 110 for complete information.

4.7 Operation Overview

NOTE:

With a liquid nitrogen cooled detector, it is good practice to turn on detector power, initiate at least one data acquisition while the detector is cooling down, and then keep the detector powered on for the entire time the dewar contains liquid nitrogen. This establishes and maintains the detector's "keep cleans" mode so that it will be continuously cleaning (i.e., shifting charge on the array to clear dark charge and cosmic ray artifacts,) even when the array is not actively acquiring data.

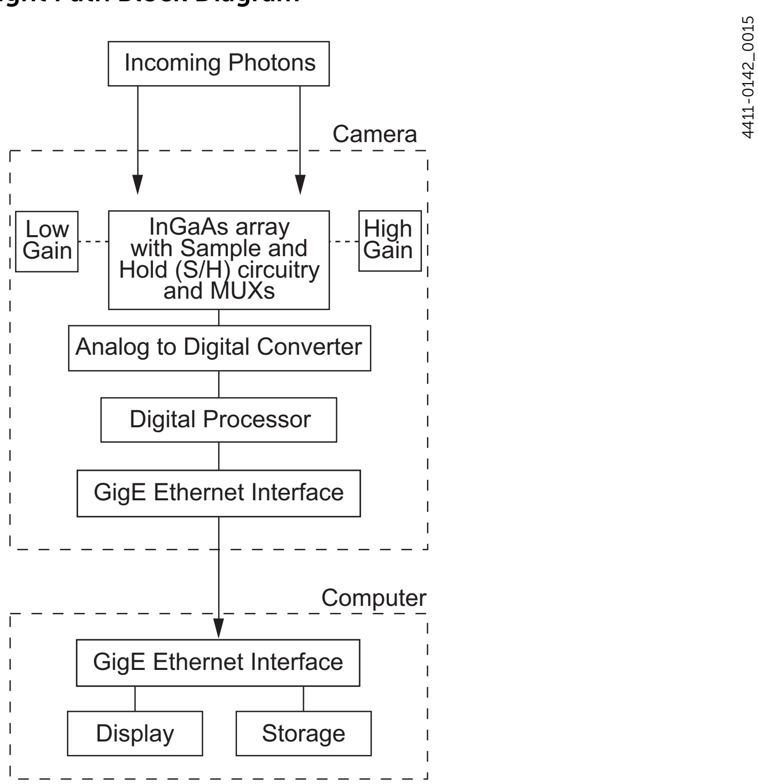
Once a PyLoN-IR detector has been installed, operation of the detector is a straightforward process for most applications:

- Establish optimal performance in Focus {Preview} mode;
- Set the camera's desired target temperature (refer to Section 7.4.1, Array Temperature Control, on page 59);
- Allow the camera's temperature to stabilize;
- Begin the acquisition of live data in Acquire mode.

During data acquisition, the sensor is exposed to a source for a specified length of time (i.e., Exposure Time,) and charge accumulates in the pixels.

After the specified exposure time has elapsed, the accumulated charge is read out of the sensor, digitized, and transferred to the host computer where it is either displayed and/or stored via the application software. This sequence is illustrated in Figure 4-6.

Figure 4-6: PyLoN-IR Light Path Block Diagram



Whether data are displayed and/or stored depends on the data collection operation that has been selected in the application software:

- Focus {Preview}

  This mode is typically used when setting up the system during First Light procedures.

  REFERENCES:

  For additional information and procedures, refer to:

  - Chapter 5, LightField First Light Procedure, on page 41;
  - Chapter 6, WinSpec/32 First Light Procedure on page 49.

  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 WinSpec/32, 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.

- Acquire

  This mode is typically used for the collection and storage of data. In Acquire mode, every frame of data collected can be automatically stored so the completed dataset may include multiple frames with one or more set of accumulations. This mode is typically 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 WinSpec/32, this can only occur in Fast Mode operation.

  REFERENCES:

  For information about synchronizing data acquisition with external devices, refer to Chapter 8, Experiment Synchronization, on page 67.

Chapter 5: LightField First Light Procedure

This chapter provides a step-by-step procedure for placing a spectroscopy system in operation for the first time when using Teledyne Princeton Instruments' LightField 64-bit data acquisition software.

NOTE:

Depending on the specific version of LightField that is being used, screen shots and/or specific instructions may vary slightly from those included in this chapter.

The intent of this procedure is to gain basic familiarity with the operation of the system and to show that it is functioning properly. Once basic familiarity has been established, operation with other configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the detector is to be operated with a spectrograph (e.g., a Teledyne Acton Research Series 2300 spectrograph,) on which the detector has been properly installed. (Refer to Appendix C, Spectrograph Adapters, on page 97 for information about mounting a spectrograph adapter to the PyLoN-IR.)

A suitable light source, such as an NeAr light source or an incandescent light bulb, should be mounted in front of the spectrograph's entrance slit.

CAUTION!

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

It is assumed that:

- The system has been installed and configured according to information included in Chapter 3, Installation, Chapter 4, Initial Setup and Operation, and Appendix C, Spectrograph Adapters;
- The reader has a basic familiarity with the application software;
- Section 4.6, Fill the Dewar, on page 36, has been read prior to filling the Dewar.;
- The system is being operated in spectroscopy mode.
- The spectrograph has an entrance slit shutter that is being controlled by the PyLoN-IR via the Shutter connector.

5.1 Hardware Setup

Perform the following procedure to set up the system:

1. Set the spectrograph entrance slit width to 25 μm.
2. Mount a light source such as a Teledyne Princeton Instruments IntelliCal source in front of the entrance slit.
3. Mount the detector to the spectrograph exit port.
4. Connect the detector shutter cable between the entrance slit shutter and the PyLoN-IR Shutter connector.
   - External Slit Shutter

     A shutter assembly mounted externally to the spectrograph has a shutter cable that plugs into the PyLoN-IR Shutter connector.
   - Internal Slit Shutter

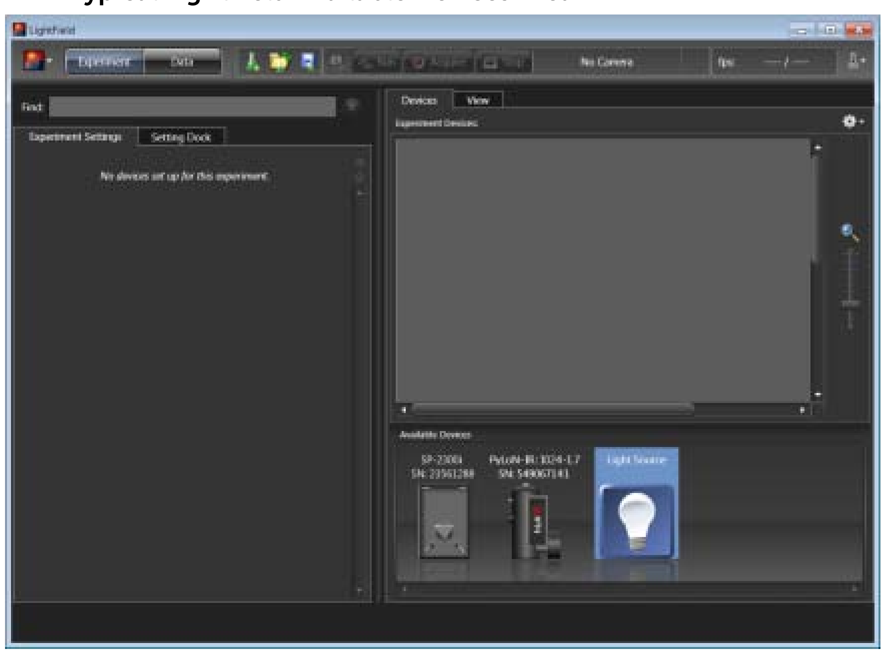
     A shutter mounted internally has an external shutter connector in the sidewall of the spectrograph. Connect a shutter cable from the PyLoN-IR Shutter connector to that connector.
5. Power ON the camera and fill the Dewar.
6. Power ON the spectrograph.
7. Turn on the host computer power.
8. Launch LightField.

5.2 Configure Parameters

Perform the following procedure to configure parameters:

1. After LightField has launched, icons representing the detector and the spectrograph are displayed in the Available Devices area. In Figure 5-1, the detector being used is a PyLoN-IR:1024-1.7 and the spectrograph is an SP-2356.

Figure 5-1: Typical LightField Available Devices Area



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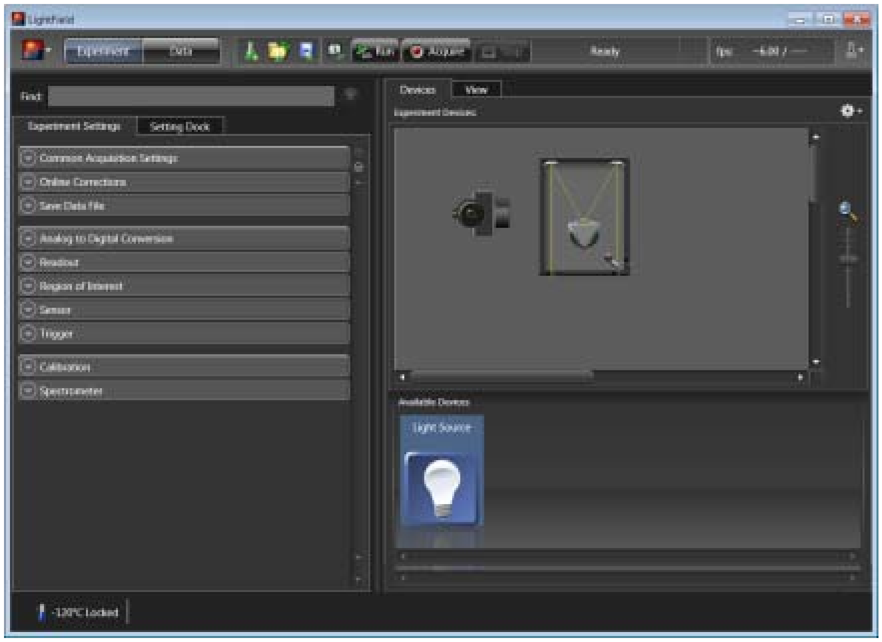
2. Drag the icons into the Experiment Devices area. See Figure 5-2.

Figure 5-2: Typical LightField Experiment Devices Area



The Experiment Settings stack to the left now displays several expanders. Because this is a new experiment, the default settings for the detector are 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. From the Shutter expander, select Shutter Mode: Normal.

5.3 Confirm System Setup

Perform the following procedure to confirm proper system setup and configuration:

1. Turn on the light source at the spectrograph entrance slit.
2. Click Run to begin previewing data. Depending on the display settings, either a spectral band (i.e., image,) or a graph should be displayed. Background noise will decrease as the camera cools to its default temperature.
3. Turn off the light source.

   Does the displayed data change to a background noise pattern or low intensity graph?

   - YES

     Light entering the spectrograph is being seen by the camera. The system may now be aligned and focused. Proceed to Section 5.4, Rotational Alignment and Focus, on page 44.

   - NO

     There is no difference between data displayed when the light source is on or off. Proceed to step 4.

4. Verify that the light source has power and is turned on.
5. Verify that the entrance slit is open a minimum of 10 μm.
6. Verify the Exposure Time on the Common Acquisition Settings expander is as required.

7. Confirm that Shutter Mode is set to Normal on the Shutter expander. If it is not, change it to Normal.
8. Check the shutter cable connections.
9. Can the shutter be heard opening and closing while operating in Run mode?
    - YES

      Turn the light source on, wait a minute, and turn the light off while viewing the data display.

      Is the issue resolved?
        - YES

          Stop acquisition and proceed to Section 5.4, Rotational Alignment and Focus, on page 44.
        - NO

          Stop data acquisition and proceed to step 10.
    - NO

      Stop data acquisition and proceed to step 10.
10. 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 instructions.

> **NOTE:**
>
> To obtain assistance, contact Customer Support. Refer to Contact Information on page 110 for complete information.

5.4 Rotational Alignment and Focus

The detector mounting hardware provides two degrees of freedom:

- Rotation;

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

Perform the following procedure to rotationally align and focus a PyLoN-IR camera with a spectrograph

1. Mount a Teledyne Princeton Instruments light source such as the IntelliCal light 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-IR mounted to the spectrograph and connected to the computer, turn on 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. Click on the Spectrometer expander. Select the appropriate grating, and set it within the region of 750 nm - 850 nm for a NeAr light. This region includes numerous spectral lines which are suitable for focus and rotational alignment procedures.
5. Set the slit to 25 μm. If necessary, adjust the Exposure Time to maintain optimum, near full-scale signal intensity.

6. Wait until the detector temperature locks at its default temperature.

NOTE:

It may be advantageous to change the Shutter Mode setting on the Shutter expander to Always Open for the following steps.

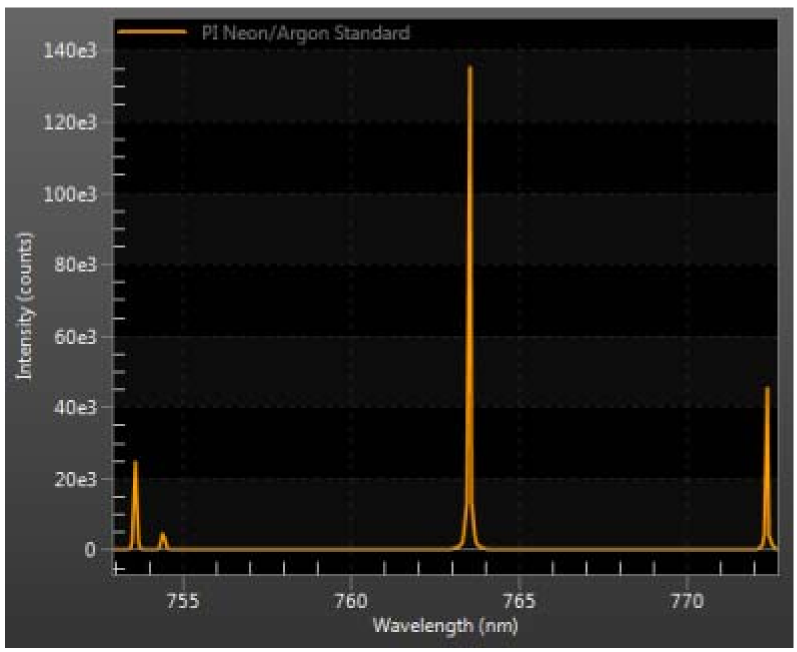
7. Verify that the spectroscopy-mount adapter moves freely at the spectrograph.
8. Review the displayed information and click the RUN button to begin data acquisition. Data will be continuously acquired and displayed but will not be stored.
9. Select a portion of the spectrum that displays multiple peaks on-screen.

   For the best overall focus and rotational alignment, a spectral window that includes three (3) peaks should be selected with the peaks positioned approximately as follows:

   - One peak is near the left edge of the display;
   - One peak is near the center of the display;
   - One peak is near the right edge of the display.

   Figure 5-3 illustrates this on-screen peak placement.

Figure 5-3: Three Spectral Peak Placement for Focus and Alignment Procedures



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10. Adjust the rotational alignment by rotating the camera while watching a live spectral display of the three peaks.

NOTE:

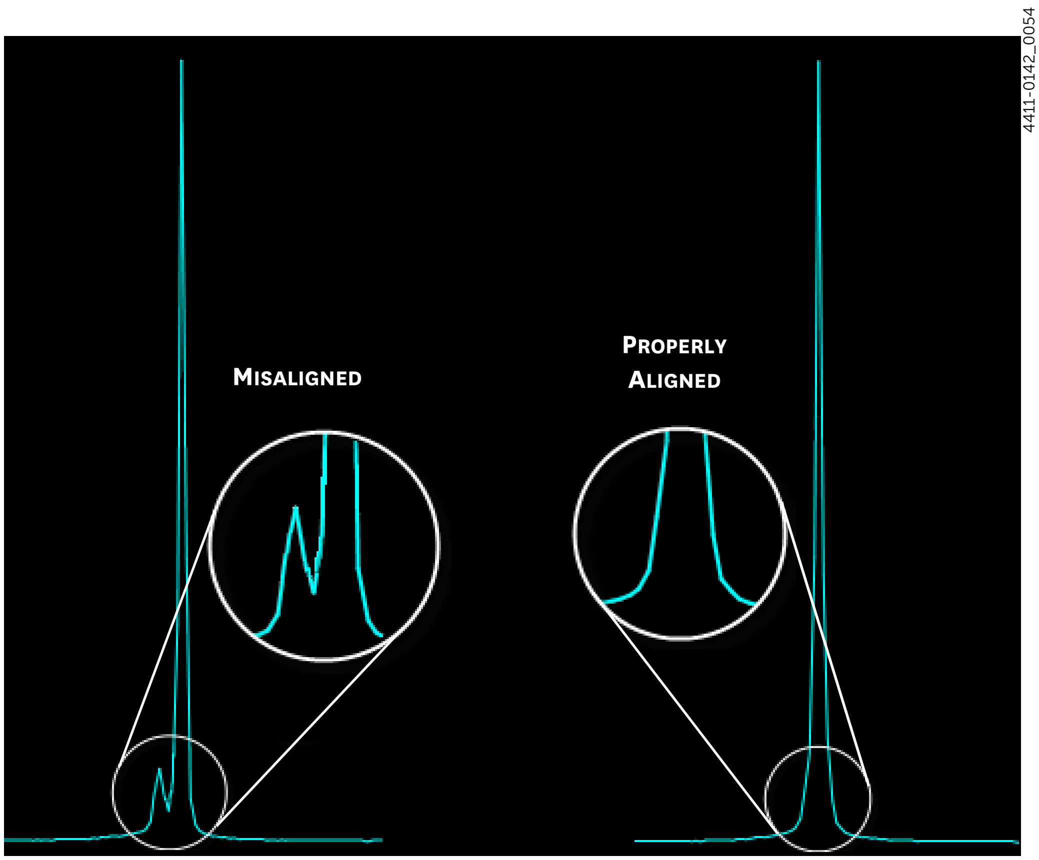
It may be necessary to loosen the set screws securing the spectrograph adapter.

The camera is properly rotationally aligned when:

- The signal strength has been maximized, and
- The spectra line widths at both the left and right edges of the focal plane are smooth and minimized.

Figure 5-4 shows an example of a spectral peaks for a rotationally misaligned system and a rotationally aligned system.

Figure 5-4: Spectral Peaks in Rotationally Misaligned and Aligned Systems



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., perform alignment and focus operations while watching a live image).

11. Slowly move the camera in and out of focus. The spectral lines should go from broad to narrow and back to broad. Maximize the intensity level and minimize the FWHM of the selected peak or peaks.

    NOTE:
    The Peak Finding function is active for the center graph to allow the FWHM information to be monitored in order to achieve the narrowest line width.

    The focusing procedure is dependent on the specific spectrograph being used:
    - Long focal-length spectrographs (e.g., Teledyne Acton Research SP-2300)
      The mounting adapter includes a tube that slides inside another tube to move the detector 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 provided by either the spectrograph or the mounting hardware, the only way to focus the system is to adjust the spectrograph's focusing mirror.
12. Tighten the spectrograph set screws to secure the spectrograph adapter.
13. Stop data acquisition.
14. If the Shutter Control setting has been set to Disable Opened, configure it back to Normal at this time.

5.5 Acquire Data

Perform the following procedure to begin acquiring data:

1. After the system has been rotationally aligned and focused, stop running in Alignment or Run mode.
2. Make any required changes to the experiment's setup and software parameters.
   Changes may include adjusting exposure time, setting up an entrance slit shutter, changing timing mode to External Sync, and/or lowering the target temperature.
3. Begin running Acquire mode.
   Data will be acquired and displayed/stored according to the experiment's configuration settings.
4. When data acquisition is complete, the detector power should remain on so the array temperature will remain locked for subsequent data acquisition.
   If no further data is to be collected, proceed to Section 5.6, Shut Down Procedure.

5.6 Shut Down Procedure

Perform the following procedure to shut down the system:

1. Before turning off the detector's power supply:
   a. For liquid nitrogen cooled systems, carefully empty the Dewar and store the liquid nitrogen that has been removed.
   b. Close LightField.
2. Turn off the detector power.

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Chapter 6: WinSpec/32 First Light Procedure

This chapter provides a step-by-step procedure for placing a spectroscopy system in operation for the first time when using Teledyne Princeton Instruments' WinSpec/32 data acquisition software The intent of this simple procedure is gain basic familiarity with the operation of the system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the detector is to be operated with a spectrograph such as the Teledyne Acton Research Series 2300i (SP2300i) on which it has been properly installed.

REFERENCES:

Refer to Appendix C, Spectrograph Adapters, on page 97 for mounting instructions.

A suitable light source, such as an NeAr light source or an incandescent light bulb, should be mounted in front of the spectrograph's entrance slit.

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 (i.e., colors.) Each wavelength leaves the grating at a different angle and is imaged by a focusing mirror onto the exit focal plane. Essentially, a spectrograph forms 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 array. 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 array, allowing the intensity at individual wavelengths to be readily measured.

This procedure assumes:

- The system has been installed and configured according to information included in Chapter 3, Installation, Chapter 4, Initial Setup and Operation, and Appendix C, Spectrograph Adapters;
- The reader has a basic familiarity with the application software;
- Section 4.6, Fill the Dewar, on page 36, has been read prior to filling the Dewar;
- The system is being operated in spectroscopy mode.
- The spectrograph has an entrance slit shutter that is being controlled by the PyLoN-IR via the Shutter connector.

6.1 WinSpec/32 On/Off Sequences

The following on/off sequences must be followed to establish and maintain the communication link between the camera and the host computer:

1. The PyLoN-IR camera must be powered ON before the WinSpec/32 is launched to ensure communication between the camera and the computer. If WinSpec/32 is started and the PyLoN-IR is not powered ON, many of the functions will be disabled and you will only be able to retrieve and examine previously acquired and stored data. WinSpec/32 must be closed before the camera is powered ON. Only after the camera has been turned on can WinSpec/32 be launched in order to configure experiments and acquire new data.
2. WinSpec/32 must be closed before powering the camera OFF. If the camera is powered OFF before closing WinSpec/32, the communication link with the camera will be broken. The program can operate in a playback mode (i.e., previously acquired data can be viewed,) but new data cannot be acquired until WinSpec/32 has been closed, the camera has been powered ON, and WinSpec/32 has been relaunched.

6.2 Hardware Setup

Perform the following procedure to set up the system hardware:

1. Set the spectrograph entrance slit width to 25 μm.
2. Mount a light source such as a Teledyne Princeton Instruments IntelliCal Hg and Ne/Ar Dual Switchable light source in front of the entrance slit.
3. Mount the PyLoN-IR detector to the spectrograph exit port.
4. Connect the shutter cable between the entrance slit shutter and the PyLoN-IR 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-IR Shutter connector to that connector.
5. Power ON the detector and fill the Dewar.

   NOTE:

   The detector must be turned on before WinSpec/32 is launched.

   WinSpec/32 must be closed before the detector is turned off.
6. Power ON the spectrograph.
7. Turn on the host computer power.
8. Launch WinSpec/32.

6.3 Configure Detector Parameters

NOTE:

This procedure is based on WinSpec/32. When using a different application, some modifications may be necessary. 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 detector parameters as indicated:

- 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 relaunch WinSpec.

- Controller ► Camera tab (Setup ► Hardware)

  Because the Camera Detection wizard installed default values appropriate for the 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 detector.
  — Camera type: This information is read from the detector.
  — Shutter type: Custom.
  — Readout mode: Full frame.

- Detector Temperature (Setup ► Detector Temperature...): -100°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. When 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
  - Clicking on Full loads the full size of the chip into the edit boxes.
  - Clicking on 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 ► Fast Mode: Safe

6.4 Configure Spectrograph Parameters

Configure spectrograph parameters as indicated:

- Define Spectrograph dialog (Spectrograph ► Define)
  - Click Install/Remove Spectrograph;
  - Highlight the appropriate spectrograph name from the list of Supported Spectrographs (e.g., Acton SP-300i for aTeledyne Acton Research SP2300i, or Acton SCT320 for an IsoPlane);
  - Click Install Selected Spectrograph.
- Move Spectrograph dialog
  - Select the grating to be moved;
  - Set it to an appropriate grating position.
    For example, set it to 763.51 nm when using an NeAr lamp with a PyLoN-IR:1024-1.7 which has a spectral range of ~750 nm to 1700 nm.

6.5 Confirm the Setup

Perform the following procedure to confirm the system setup and 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, either a spectral band (i.e., image,) or a graph should be displayed. Background noise will decrease as the camera cools to its default temperature.
3. Turn off the light source.
   Does the displayed data change to a background noise pattern or low intensity graph?
   - YES
     Light entering the spectrograph is being seen by the camera. The system may now be aligned and focused. Proceed to Section 6.6, Rotational Alignment and Focusing, on page 53.
   - NO
     There is no difference between data displayed when the light source is on or off. Proceed to step 4.
4. Verify that the light source has power and is turned on.
5. Verify that the entrance slit is open a minimum of 10 μm.
6. Verify the Exposure Time on the Experiment Setup Timing tab is as required.

7. Confirm that Shutter Control is set to Normal on the Experiment Setup Timing tab. If it is not, change it to Normal.
8. Check the shutter cable connections.
9. Can the shutter be heard opening and closing while running in Focus mode?
   - YES
     Turn the light source on, wait a minute, and turn the light off while viewing the data display.
     Is the issue resolved?
     — YES
       Stop acquisition and proceed to Section 6.6, Rotational Alignment and Focusing, on page 53.
     — NO
       Stop data acquisition and proceed to step 10.
   - NO
     Stop data acquisition and proceed to step 10.
10. 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 instructions.

NOTE:
To obtain assistance, contact Customer Support. Refer to Contact Information on page 110 for complete information.

6.6 Rotational Alignment and Focusing

The detector mounting hardware provides two degrees of freedom:

- Rotation;
  Rotation is 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 detector back and forth through the focal plane of the spectrograph while watching a live display. The approach taken is to slowly move the detector in and out of focus and adjust for optimum focus.

Perform the following procedure to rotationally align and focus a PyLoN-IR camera with a spectrograph:

1. Mount a Teledyne Princeton Instruments light source such as the IntelliCal light 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-IR 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 an appropriate grating, and set it within the region of 750 nm - 850 nm for a NeAr light. This region includes numerous spectral lines which are suitable for focus and rotational alignment procedures.

REFERENCES:

Refer to Section 6.4, Configure Spectrograph Parameters, on page 52 for information about defining a spectrograph and moving the grating.

5. Set the slit to 25 μm. 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.

NOTE:

It may be advantageous to change the Shutter Control setting to Disable Opened for the following steps.

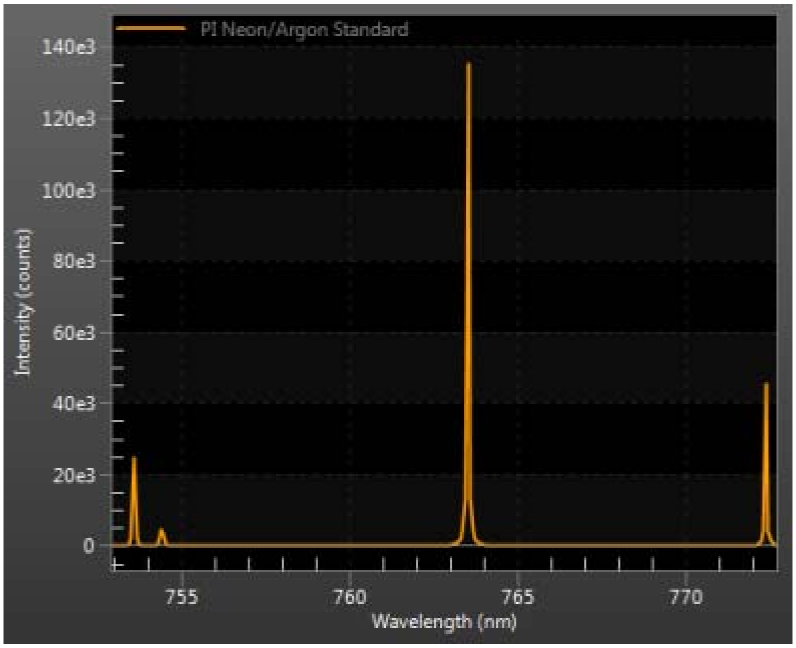
7. Select Focus on the Acquisition menu or the Experiment Setup dialog to begin data accumulation.

   Data will be continuously acquired and displayed but will not be stored until you stop acquisition and use the Save function on the File menu.
8. Adjust the WinSpec settings to display multiple peaks on-screen.

   For the best overall focus and rotational alignment, a spectral window that includes three (3) peaks should be selected with the peaks positioned approximately as follows:
   - One peak is at or near the left edge of the display;
   - One peak is at or near the center of the display;
   - One peak is at or near the right edge of the display.

   Figure 6-1 illustrates this on-screen peak placement.

Figure 6-1: Three Spectral Peak Placement for Focus and Alignment Procedures



9. Adjust the rotational alignment by rotating the camera while watching a live spectral display of the three peaks.

NOTE:

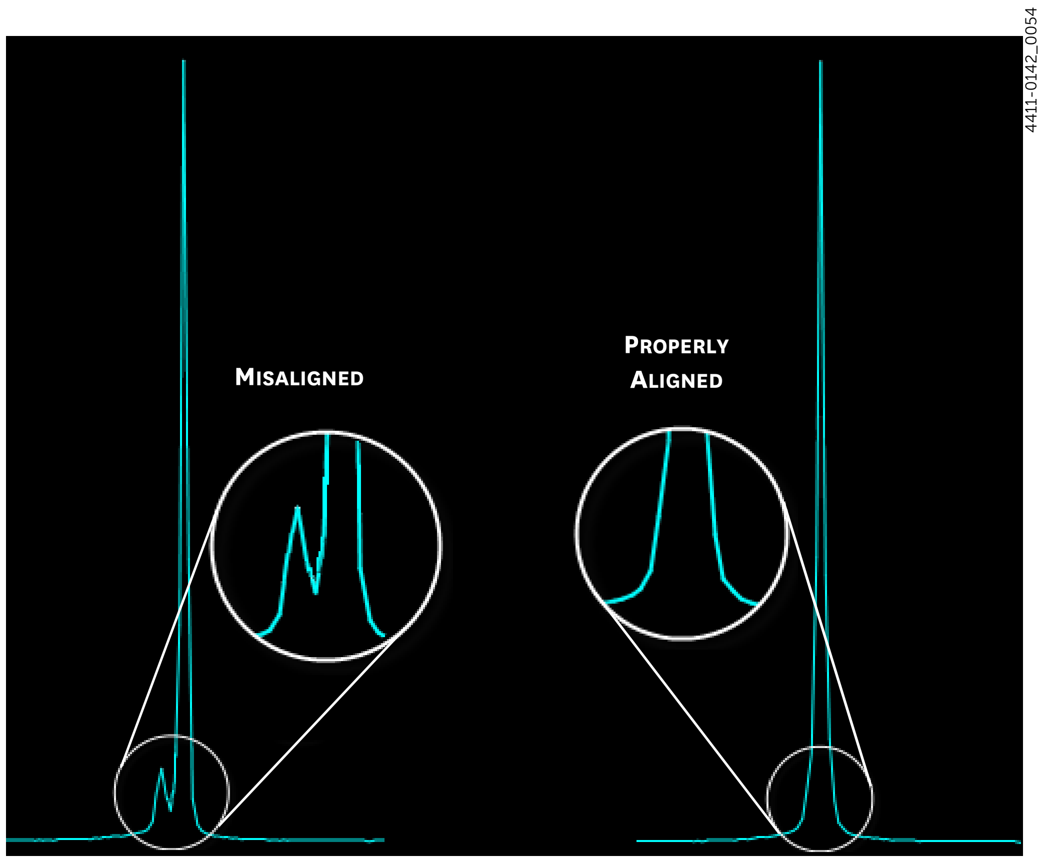
It may be necessary to loosen the set screws securing the spectrograph adapter.

The camera is properly rotationally aligned when:

- The signal strength has been maximized, and
- The spectra line widths at both the left and right edges of the focal plane are smooth and minimized.

Figure 6-2 shows an example of a spectral peaks for a rotationally misaligned system and a rotationally aligned system.

Figure 6-2: Spectral Peaks in Rotationally Misaligned and Aligned Systems



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., perform alignment and focus operations while watching a live image).

10. Slowly move the camera in and out of focus. The spectral lines should go from broad to narrow and back to broad. Leave the detector set for the narrowest achievable line. It is suggested that the Focus Helper function (Process ► Focus Helper...) be used to determine the narrowest line width since it can automatically locate peaks and generate a report on peak characteristics during live data acquisition.

    REFERENCES:

    Refer to WinSpec/32 online help for additional information.

    The focusing procedure is dependent on the specific spectrograph being used:

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

      The mounting adapter includes a tube that slides inside another tube to move the detector 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 provided by either the spectrograph or the mounting hardware, the only way to focus the system is to adjust the spectrograph's focusing mirror.
11. Tighten the spectrograph set screws to secure the spectrograph adapter.
12. Stop data acquisition.
13. If the Shutter Control setting has been set to Disable Opened, configure it back to Normal at this time.

6.7 Acquire Data

Perform the following procedure to begin acquiring data:

1. After the system has been rotationally aligned and focused, stop running in Focus mode.
2. Make any required changes to the experiment's setup and software parameters.

   Changes may include adjusting exposure time, setting up an entrance slit shutter, changing timing mode to External Sync, and/or lowering the target temperature.
3. Begin running Acquire mode.

   Data will be acquired and displayed/stored according to the experiment's configuration settings.
4. When data acquisition is complete, the detector power should remain on so the array temperature will remain locked for subsequent data acquisition.

   If no further data is to be collected, proceed to Section 6.7.1, Shut Down Procedure.

6.7.1 Shut Down Procedure

Perform the following procedure to shut down the system:

1. Before turning off the detector's power supply:
   a. For liquid nitrogen cooled systems, carefully empty the Dewar and store the liquid nitrogen that has been removed.
   b. Close WinSpec/32.
2. Turn off the detector power.

Chapter 7: Exposure and Signal

This chapter discusses the various factors that affect the signal acquired on an array, including array architecture, exposure time, temperature, and saturation.

7.1 Array Architecture

A linear photodiode array (PDA) can be thought of as a one-dimensional array of photodiodes attached to an integrated circuit (IC) chip. For spectroscopy, a PDA is placed at the image plane of a spectrograph to allow a range of wavelengths to be detected simultaneously.

Each sensor on a PDA is connected to its own charge storage well. These sensors respond to the intensity of light or infrared (IR) radiation falling on their collection areas and store a proportional amount of charge in their associated wells. Once charge accumulates for the specified exposure time that has been configured within the software, the charge in each well is read out serially.

7.2 Exposure Time

Exposure, which is configured 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 detector. In combination with triggers, these commands control when continuous cleaning of the array stops and when the accumulated signal will be readout. The continuous cleaning prevents buildup of dark current and unwanted signal prior to the event of interest. At the end of the exposure time, the array is read out and cleaning starts again.

NOTE:

The PyLoN-IR camera has a minimum exposure time of 20 μs.

7.2.1 Exposure with External Shutter

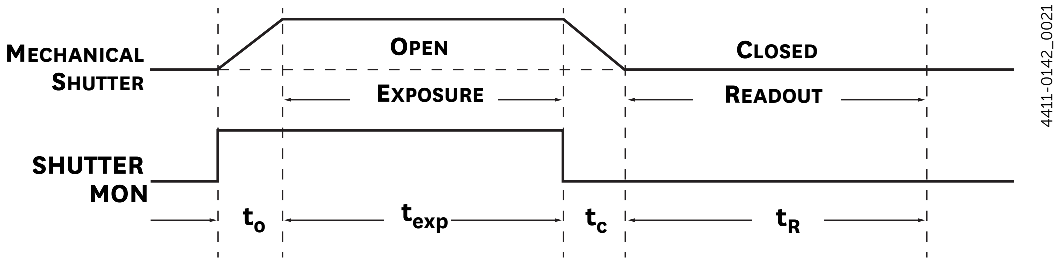
When a camera does not have an internal shutter, either the light source must be controlled or an external shutter must be used to block light from the array during readout. If the light source can be electronically controlled using the SHUTTER MON output, the CCD can be read out in darkness.

Another way to prevent light from falling on the array during readout is to use a Teledyne Princeton Instruments supplied 25 mm external shutter which is typically used at a spectrograph entrance slit. This shutter can then be controlled by the camera and is synchronized with the exposure-readout cycle as shown in Figure 7-1. The shutter compensation time (t_c) is approximately 8 ms for the 25 mm shutter.

NOTE:

When acquisition time is on the order of ~130 μs at 2 MHz or ~510 μs at 500 kHz, the addition of the 8 ms shutter compensation time slows the readout time, thus reducing the number of frames per second. To minimize the impact of shutter compensation time, disable shutter open in software.

Figure 7-1: Timing Diagram: Mechanical Shutter and SHUTTER MON



In Figure 7-1:

- t_{exp} = Exposure Time;
- t_o = Shutter Open Compensation Time;
- t_c = Shutter Close Compensation Time;
- t_R = Readout Time
- SHUTTER MON is the output of the SHUTTER MON connector on the Aux I/O cable, and the TTL_{out} connector when Shutter is selected.

7.3 Noise Sources

Primary noise sources include:

- Dark signal - IR signal from the environment and leakage current
- Input signal - photon shot noise
- Readout - noise generated when the multiplexers are read out

The ideal detector contains no noise sources and is limited only by the photon shot noise. Unfortunately, there are always noise sources that will contribute noise of one kind or another to the total signal. The methods used to reduce the noise depend on the noise component being addressed. Infrared noise from the detector and the environment can be reduced by lowering the temperature of the detector and environment, respectively.

7.4 Cooling an Array

Detectors in the PyLoN-IR family are cryogenically-cooled. With cryogenic cooling, the array can be operated at temperatures in the range of 50°C to -100°C, but the pixel gain and offset corrections will be best when the camera is at its default temperature of -100°C. Generally speaking, the lower the array temperature, the lower the dark current and, therefore, the greater the sensitivity.

Cryogenically-cooled detectors use liquid nitrogen to reduce the temperature of the array. 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 detector monitors the chip temperature.

CAUTION!

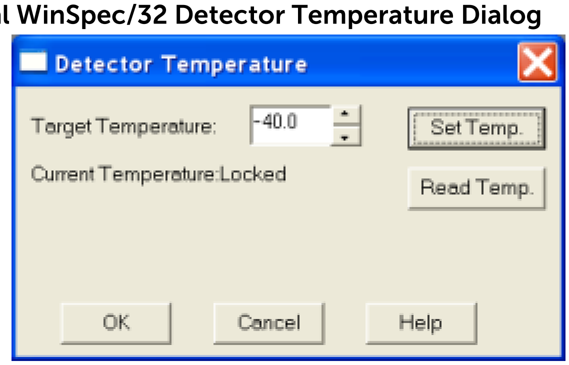
Cryogenically-cooled detectors, because of their low operating temperatures, must always be connected to a powered ON detector. If the detector power is turned off with liquid nitrogen remaining in the Dewar, the array temperature will drop below the array's normal operating temperature of -100°C. The array will not work correctly until the power is turned back on and the array is warmed back up to -100°C.

7.4.1 Array Temperature Control

Lowering the temperature of an array generally enhances the quality of the acquired signal.

- When WinSpec/32 is the controlling software, temperature control is achieved using the Setup ► Detector Temperature shown in Figure 7-2.
- When Light Field is being used, temperature control is done on the Sensor expander.

Figure 7-2: Typical WinSpec/32 Detector Temperature Dialog



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

The deepest operating temperature for a system depends on the array size and packaging; and the time required to achieve lock can vary over a considerable range, depending on such factors as the detector type, array type, ambient temperature, etc. 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 does not display temperature information during data acquisition.

7.5 Background Subtraction

Background subtraction removes a fixed noise pattern from the integrated signal.

In the case of the InGaAs PDA, the fixed pattern noise is due to material variations that cause pixel input offset voltages to vary. The input offset voltage of a photodiode may be:

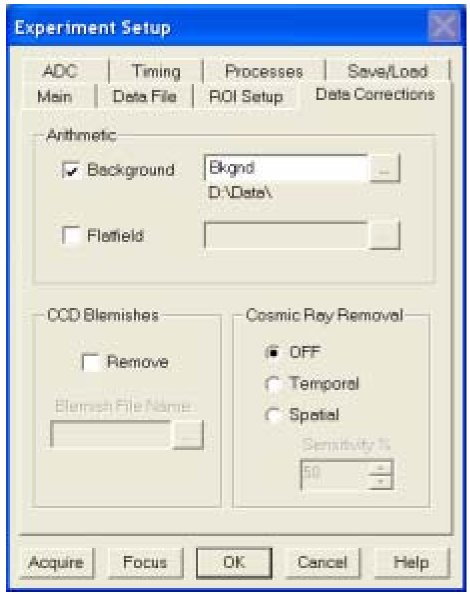
- Zero Bias;
  No dark current;
- Reverse Bias;
  Dark current with the same bias as the photo current.
- Forward Bias;
  Dark current opposite to the photocurrent.

The pixel-pixel variation is repeatable from one readout of the array to the next provided the array is maintained at the same temperature, the same experiment settings are being applied, and ambient conditions do not change. Because the pixel-to-pixel variation is not random electrical noise, it can be removed by background subtraction.

When acquiring a background to be subtracted, the identical experiment settings are used but the experiment's signal source remains OFF. After the background has been saved, background subtraction can be set up to occur automatically as part of the data acquisition process, or the background data can be subtracted from the experiment signal as a post-acquisition process. Subtracting the background removes the dark signal (ambient signal and dark current component) of the signal data.

Figure 7-3 illustrates the configuration of Automatic Background Subtraction in WinSpec/32.

Figure 7-3: Typical WinSpec/32 Automatic Background Subtraction Dialog

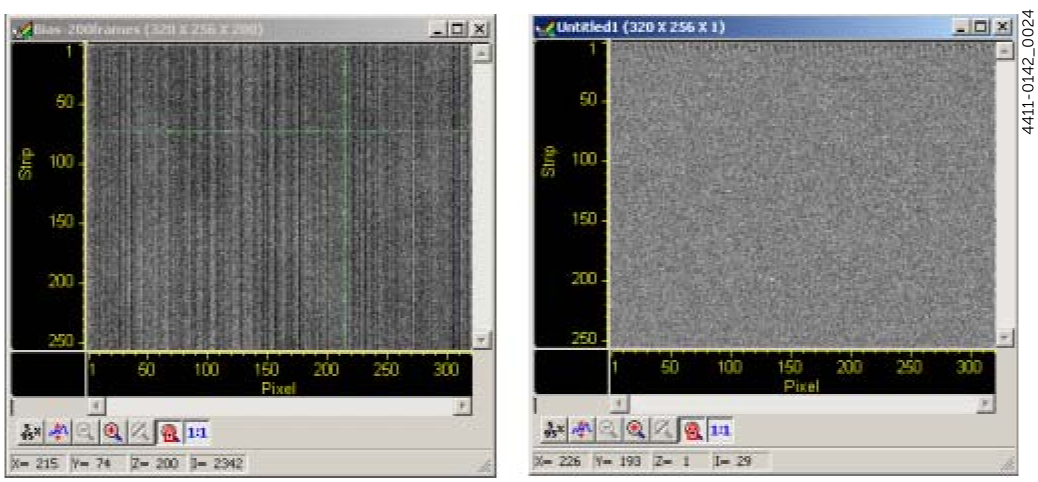


NOTES:

1. Although a pattern is repeatable, its profile will change from temperature setting to temperature setting. Therefore, both the background data and the experiment data MUST be acquired at the same locked temperature.
2. In situations where uncorrected/raw data is required, perform background subtraction as a post-acquisition process.

Figure 7-4 compares an unprocessed image with the same image after background subtraction has been applied.

Figure 7-4: Image Comparison: Unprocessed vs. Background Subtraction



UNPROCESSED IMAGE **IMAGE AFTER BACKGROUND SUBTRACTION**

7.6 Flatfield Correction

The application of Flatfield Correction compensates for any non-uniformity of illumination sources and/or non-uniformity of the InGaAs detector. Applying a flatfield correction is a three-step process:

- A reference flatfield image must be acquired and saved;
- The data acquisition software must be configured to automatically apply the acquired reference image;
- Experiment data are acquired and the flatfield data are applied.

Perform the following procedure to apply flatfield correction to acquired experiment data:

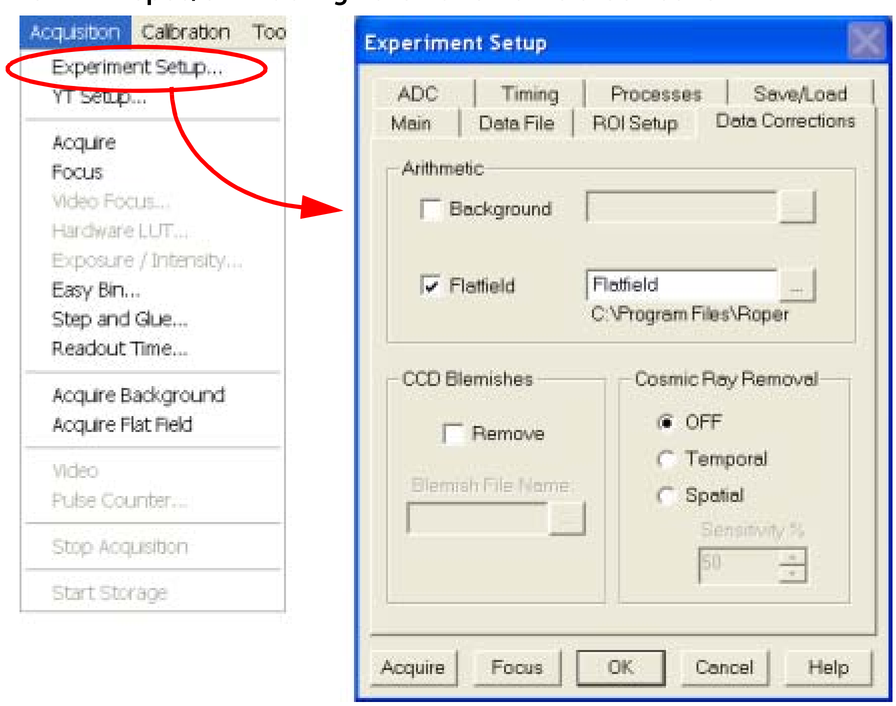
1. Configure experiment parameters within the data acquisition software.
2. Wait until the detector has reached its operating temperature to ensure stability.
3. Acquire a flatfield reference image of the illumination source without applying an input source/sample.
4. Save the acquired flatfield reference image on the host computer's hard drive.
5. Configure the data acquisition software to automatically apply the specified flatfield file to newly acquired data.

   Figure 7-5 illustrates how to enable automatic flatfield correction within WinSpec/32.

REFERENCES:

Refer to the LightField User's Manual listed in Table 1-1 on page 9 for information about enabling automatic flatfield corrections.

Figure 7-5: WinSpec/32 Enabling Automatic Flatfield Correction



4411-0142_0025

6. Configure the experiment with the sample in place and acquire data.

   The flatfield data will be automatically applied to the raw data, and the resulting data will be displayed and/or stored.

7.7 Dark Signal

Dark signal is a buildup of charge on the array over time. Even with light into the detector completely blocked, the array will collect a dark signal that is dependent on the exposure time, detector temperature, and a variety of other factors. The longer the exposure time and the warmer the detector, the larger and less uniform this background will appear. Thus, to minimize dark signal effects, the detector temperature should be set for the lowest temperature within the recommended range for the detector. For PyLoN-IR, a default temperature of -100ºC provides the best performance.

Dark signal values vary widely from one array to another and are temperature dependent.

NOTE:

Dark signals are fully subtractable readout patterns. Refer to Section 7.5, Background Subtraction, on page 60 for complete information.

CAUTION!

If a sudden change in the baseline signal is observed, there may be excessive humidity in the vacuum enclosure of the detector. Immediately turn off the controller, and if using an LN-cooled camera, remove the liquid nitrogen.

Next, contact Teledyne Princeton Instruments Customer Support for further instructions. Refer to Contact Information on page 110 for complete contact information.

7.8 Saturation

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

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

7.9 Readout

Two factors to be considered with respect to array readout are:

- Region of Interest (ROI);
  ROI selection allows a section of an array to be specified and its data read out and saved. All data not included in the specified ROI are read out and discarded.
- Analog gain control.
  Analog gain control determines how many photons are required to generate an analog-to-digital unit. The gain choice should be based on the signal intensity.

7.9.1 Region of Interest (ROI)

PyLoN-IR supports Region of Interest (ROI) or area selection. While there will be no increase in readout speed, there will be a reduction in the size of the data set.

Restrictions on ROI selection are:

- An ROI must contain a whole multiple of four pixels (i.e., 4, 8, 12, 16, ... pixels.)
- The starting pixel in an ROI must be at a four-pixel boundary.
  For example, pixel 1, pixel 5, pixel 9, pixel 13, and so on are valid starting pixels. Pixel 2, pixel 4, pixel 8, and pixel 15 are not valid.

7.9.2 Controller Gain {Analog Gain}

Analog gain control is used to change the number of electrons required to generate an Analog-to-Digital Unit (ADU) which is also known as a count.

NOTE:

In WinSpec/32, valid Controller Gain choices for PyLoN-IR detectors are:

- 1;
- 2.

In LightField, valid Analog Gain choices are:

- Low;
- High.

Users who measure high-level signals may wish to select 1 {Low} to allow digitization of larger signals. Users who consistently measure low-level signals may wish to select 2 {High}, which requires fewer electrons to generate an ADU and reduces some sources of noise. This is a particularly important consideration in absorbance measurements.

This technique is also useful in high light level experiments where the detector 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.

NOTE:

In WinSpec/32, Gain Selection is configured on the Experiment Setup ► ADC tab.

In LightField, Gain Selection is configured on the Analog to Digital Conversion expander.

7.9.2.1 Example

It is assumed that the actual incoming light level is identical in both instances.

NOTE:

The numbers used do not reflect actual values for a PyLoN-IR and do not reflect actual detector performance.

- 1 {Low} requires 1750 electrons to generate one ADU. Strong signals can be acquired without flooding the sensor. If the gain is set to Low and the spectra or images appear weak, you may want to change the gain setting to 2 {High}.
- 2 {High} requires 65 electrons 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 sensor appears to be flooded with light, you may want to change the setting to 1{Low}.

7.10 Digitization

After gain has been applied to a signal, the Analog-to-Digital Converter (ADC) converts that analog information (i.e., continuous amplitudes,) into a digital data (i.e., quantified, discrete steps,) that can be read, displayed, and stored by the application software. The number of bits per pixel is based both on the hardware and the settings programmed into the detector through the software. Refer to Section 7.9, Readout, on page 64 for additional information.

Factors associated with digitization include the digitization rate and baseline signal. Depending on the detector model, it may be possible to change the speed at which digitization occurs and/or offset the baseline. These factors are discussed in the following sections.

7.10.1 Digitization Rate

After readout, an analog signal representing the charge of each pixel is digitized. The number of bits per pixel is based on both the hardware and the settings programmed into the detector through the software. A 1 MHz A/D converter is standard for the PyLoN-IR spectroscopy array.

7.10.2 ADC Offset (Baseline Offset)

ADC offset, also known as baseline offset, provides another way of dealing with dark signal. Refer to Section 7.7, Dark Signal, on page 63 for additional information. By offsetting the baseline signal, much of the background is ignored during conversion. For the PyLoN-IR, this offset is set at the factory and is not user changeable.

During the exposure time, in addition to the signal of interest, the array collects a charge pattern and an IR signal. The longer the exposure time and the warmer the detector/environment, the larger and less uniform this background will appear.

CAUTION!

If a sudden change in the baseline signal is observed, there may be excessive humidity in the vacuum enclosure of the detector. Immediately turn off the controller, and if using an LN-cooled camera, remove the liquid nitrogen.

Next, contact Teledyne Princeton Instruments Customer Support for further instructions. Refer to Contact Information on page 110 for complete contact information.

All PyLoN-IR arrays have been tested for uniformity and do not exhibit any vignetting (i.e., reduction of response,) at the extreme ends of the array. If a reduction in response is measured across the array, it may be the result of one or more of the following conditions:

- Water condensation has occurred on the edges of the Dewar window. This will occur only when the previously described cooling/pumping instructions have not been followed or if the Dewar itself has sprung a leak (very rare.)
- The spectrograph is not illuminating the full photoactive area of the array. Most spectrographs provide at least a 1" wide focal plane that should cover the full array. If the exit port has been masked, the full focal plane may not be available.

7.11 Software Binning

Binning is the process of summing data from adjacent pixels to form a single pixel that is often called a Super Pixel. Because InGaAs arrays do not have a serial register or a summing node, binning is accomplished in software after data have been read out and digitized.

Software binning can be configured to occur automatically from the Acquisition ► Experiment Setup ► ROI Setup tab {Region of Interest expander}.

The advantage of software binning is that it can improve the S/N ratio by as much as the square root of the number of scans. Unfortunately, with a large number of scans (i.e., greater than 100,) detector 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 achieved. Again, background subtraction from the data is necessary.

Chapter 8: Experiment Synchronization

Previous chapters have described the configuration of hardware and software for basic operation. This chapter discusses the following topics associated with experiment synchronization:

- Shutter Control Modes;
- Timing {Trigger Response} Modes;
- Fast Mode;
- TTL OUT Control.

Depending on the data acquisition software being used, experiment synchronization parameters are located as follows:

- WinSpec/32: Parameters are found on the Experiment Setup ► Timing tab.
- LightField: Parameters are found on the Shutter and Trigger expanders.

8.1 Shutter Control Modes

When an external entrance slit shutter is being controlled by PyLoN-IR, shutter operation can be coordinated with the experiment. Available shutter control modes for Full Frame operation are:

- Normal;
- Disable Closed {Always Closed};

  When selected, the shutter will not operate during the experiment and remains in the closed position. This option is useful when making dark signal measurements of the background, or when no shutter is present in the system.

  NOTE:

  The red SHUTTER FAULT LED on the PyLoN-IR power supply illuminates when the shutter is in the Disable Closed {Always Open} state.

- Disable Opened {Always Open};

  When selected, the shutter will not operate during the experiment and remains in the open position.
- Pre Open {Open Before Trigger}.

  This mode is available only when the selected Timing {Trigger Response} Modes is:

  — External Sync {Readout Per Trigger};

  — Trigger Start {Start On Single Trigger}.

  When selected, the shutter opens as soon as the detector's internal controller is ready to receive trigger. This is required if the time between the trigger and the event is less than a few milliseconds, the time it takes the shutter to open.

8.2 Timing {Trigger Response} Modes

PyLoN-IR's Timing {Trigger Response} modes for Full Frame operations are:

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

Timing mode, when combined with the Shutter Control {Shutter Mode} options, provide the widest variety of modes for precision experiment synchronization.

8.2.1 External Trigger Input

The selected Timing Mode {Trigger Response} determines how the camera responds to a trigger received on the TRIGGER IN signal through the AUX I/O port on the rear of the camera. See Figure 8-1.

Figure 8-1: PyLoN-IR Rear-Panel Connectors

Things to keep in mind when setting up the trigger input are:

- 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 Edge (+) or Falling (-) Edge must be specified on the Experiment Setup ► Timing tab {Trigger expander}.

8.2.2 Free Run {No Response}

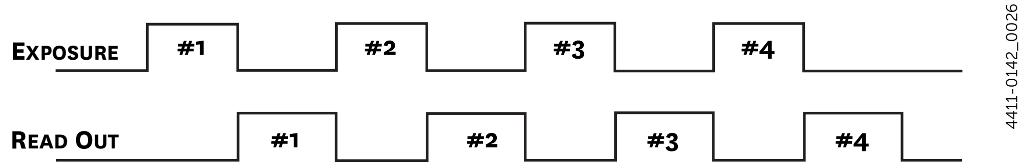
In this mode, there is no external triggering or the camera ignores external triggers, and all settings are obtained from the setup parameters, making the duration of each exposure time constant and the interval times between exposures constant.

NOTE:

In this timing mode, all shutter modes behave the same way.

See Figure 8-2 for the timing diagram for this mode.

Figure 8-2: Timing Diagram: Free Run {No Response}



8.2.3 Bulb Trigger {Expose During Trigger Pulse} Timing

When Bulb Trigger {Expose During Trigger Pulse} timing is selected, the camera exposure is determined by an external trigger received on the TRIGGER IN signal through the AUX I/O port (see Figure 8-1) which allows an external timing generator to control the exposure time of the camera.

In Full Frame mode, the transition from the inactive state to the active state of the external trigger starts the exposure, while the transition from the active state to the inactive state ends the exposure.

When the camera is ready to accept the external sync through the TRIGGER IN signal, the Wait for Trigger {Waiting For Trigger} (WFT) signal at the AUX I/O port's TTL OUT signal 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 the 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 on the TRIGGER IN signal before entering a continuous clean cycle. If none has occurred, a cycle will begin and complete. The Trigger In signal is checked again to determine if an active edge has occurred. Exposure will begin if it has.

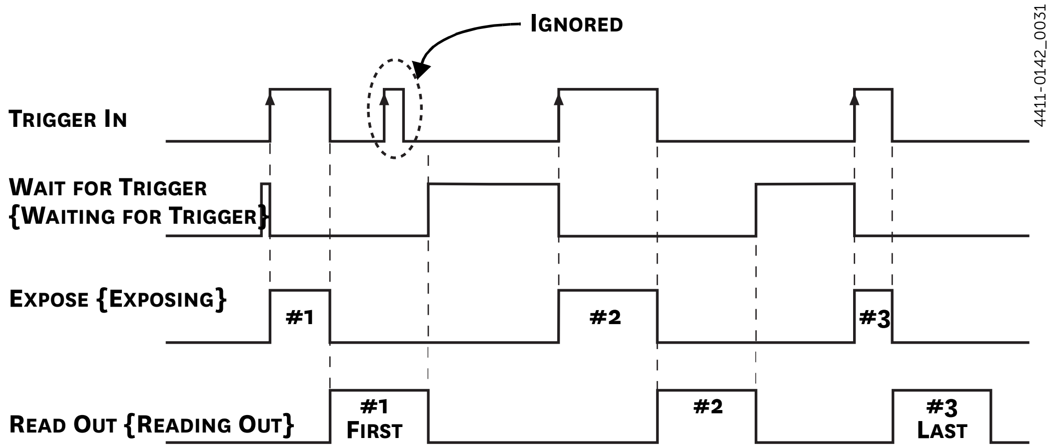
NOTE:

Continuous Clean is executed only on the first trigger within a sequence. Subsequent triggers will not initiate the Continuous Clean Programmed pattern.

Figure 8-3 illustrates the timing diagram for Bulb Trigger {Expose During Trigger Pulse} mode with the following configuration settings:

- Non-Overlap Mode;
- Three Exposure Sequence;
- No Pre Open {Open Before Trigger};
- No Continuous Cleans {Clean Until Trigger}.

Figure 8-3: Timing Diagram: Bulb Trigger {Expose During Trigger Pulse}



8.2.4 External Sync {Readout Per Trigger}

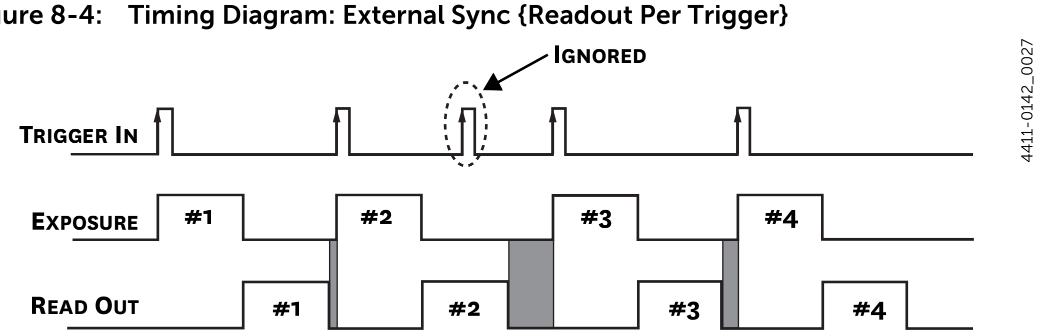
In this mode, each frame within a sequence requires a trigger. Each frame is exposed for the length of time specified within the software and is then read out. If a trigger arrives during the exposure-readout cycle for the previous frame, it is ignored.

NOTE:

For a sequence of a single frame, both Bulb Trigger {Expose During Trigger Pulse} and Trigger Start {Start on Single Trigger} modes are equivalent to External Sync {Readout Per Trigger} mode.

Figure 8-4 illustrates the timing diagram for this mode. Shaded areas indicate the idle time between exposures.

Figure 8-4: Timing Diagram: External Sync {Readout Per Trigger}



8.2.5 External Sync {Readout Per Trigger} with Continuous Cleans {Clean Until Trigger} Timing

Another timing mode supported by PyLoN-IR is Continuous Cleans {Clean Until Trigger}. In addition to the standard cleaning of the array that occurs after the camera has been enabled, this mode removes any accumulated charge from the array up until the moment the External Sync pulse is received. Once the External Sync pulse has been received, cleaning of the array stops as soon as the current row has been shifted, and frame collection begins.

- With Normal shutter operation, the shutter is opened for the set exposure time.
- With Pre Open {Open Before Trigger} shutter operation, the shutter is open during the Continuous Cleaning {Clean Until Trigger}.

Once the External Sync pulse has been received, the shutter remains open for the prescribed 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 has been completed to prevent the CCD from becoming out of sync.

As expected, response latency is on the order of one vertical shift time (i.e., 1-30 μs 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's 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 with the single vertical shift time.

Figure 8-5 and Figure 8-6 illustrate the timing diagrams for this timing mode for WinSpec/32 and LightField, respectively. Figure 8-7 is a high-level flowchart of the overall process.

Figure 8-5: Timing Diagram: WinSpec/32 Continuous Cleans

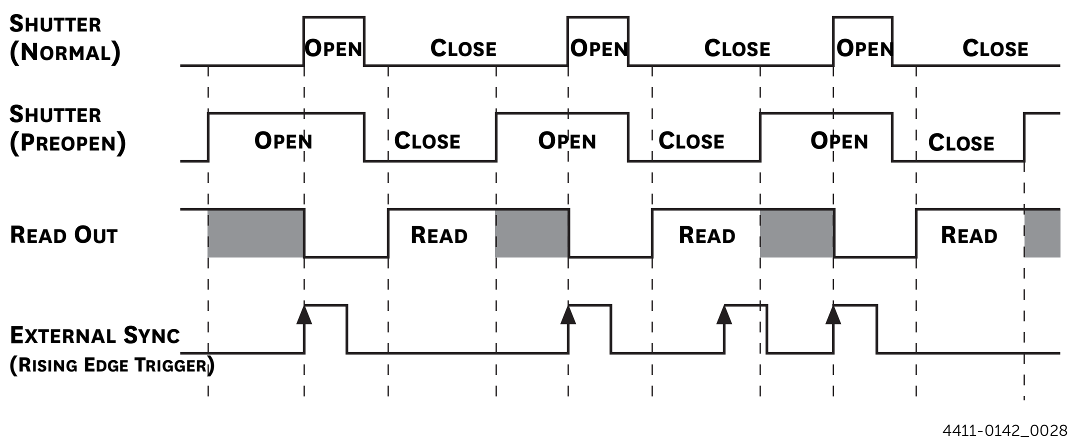


Figure 8-6: Timing Diagram: LightField Clean Until Trigger (CUT)

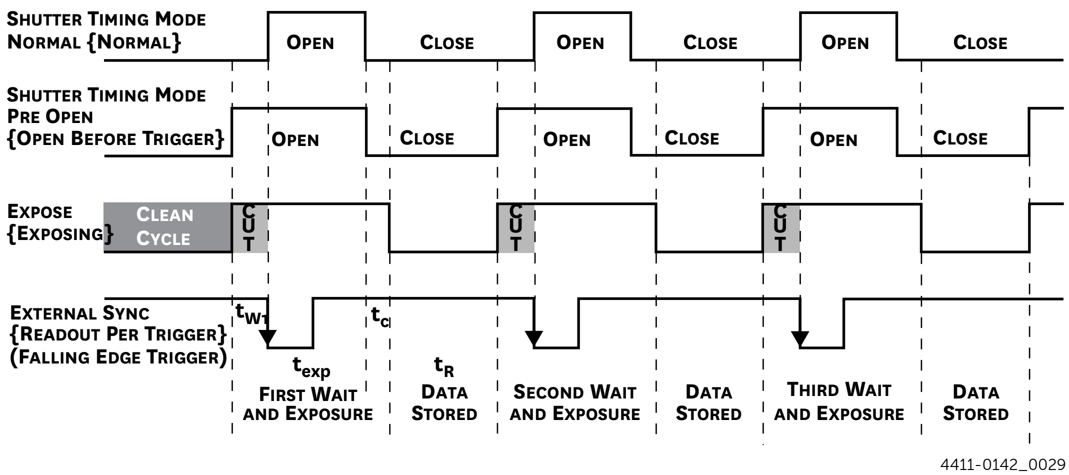
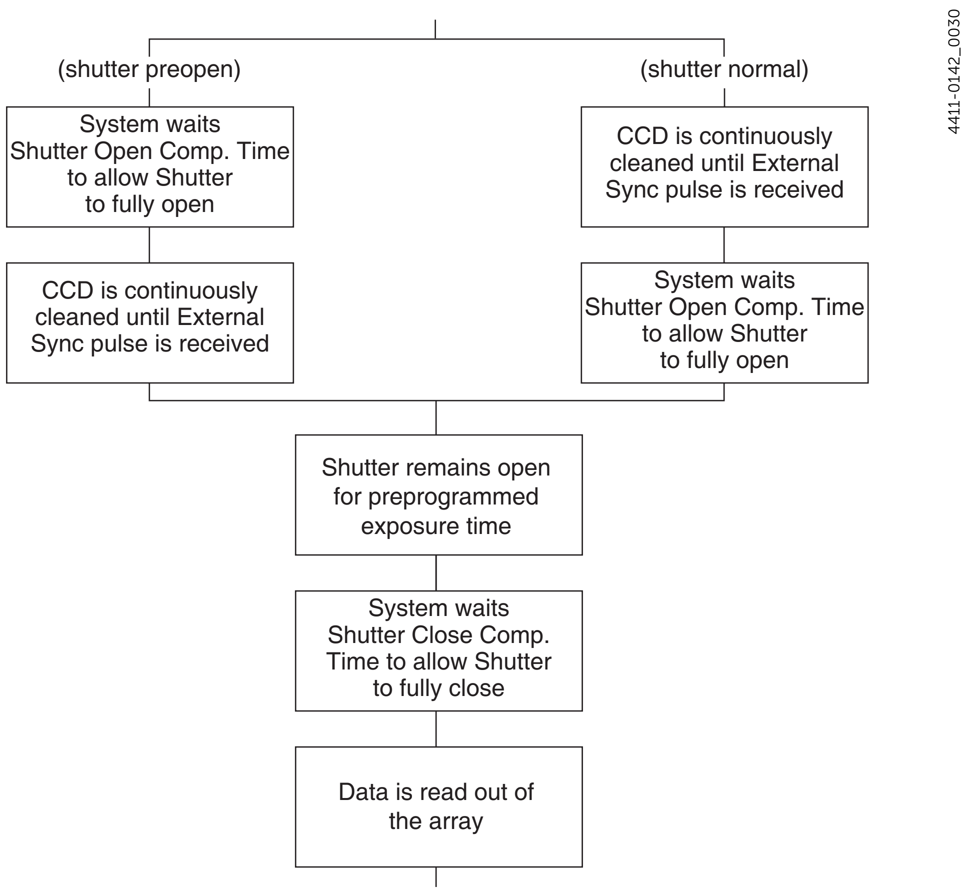


Figure 8-7: Flowchart: Continuous Cleans {Clean Until Trigger}



8.2.6 Trigger Start {Start On Single Trigger}

In this mode, the camera requires only one trigger to acquire a sequence of frames. Once the initial trigger has been received, the camera ignores any further triggers until the entire exposure/readout sequence has been completed.

8.3 Fast Mode

When operating in Fast Mode, PyLoN-IR runs according to the timing of the experiment, with no interruptions from the computer. Fast operation is primarily intended for collecting real-time sequences of experimental data where timing is critical and events cannot be missed. Once the PyLoN-IR has sent the start command by the computer, all frames are collected without further intervention from the computer.

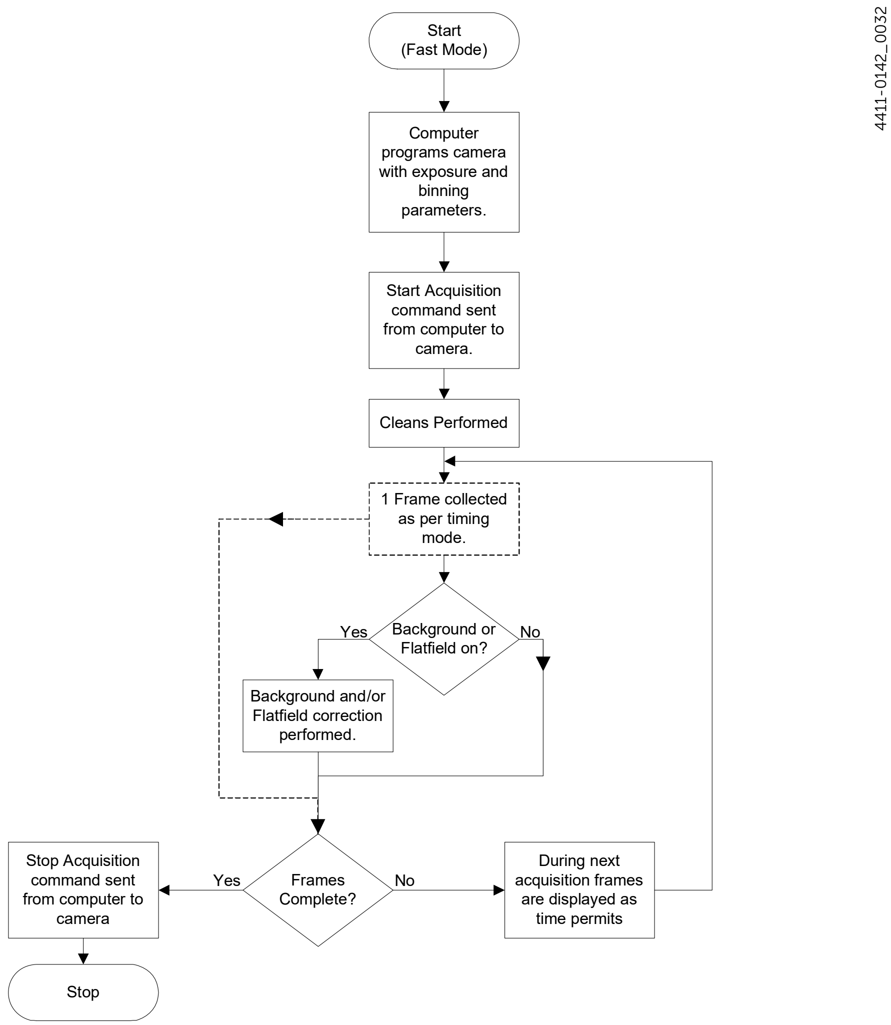
The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the computer only displays frames when it is not performing other tasks. Image display has a lower priority, so the image on the screen may lag several images behind. A second drawback is that a data overrun may occur if the number of images collected exceeds the amount of allocated RAM, or if the computer cannot keep up with the data rate.

NOTE:

Only Fast Mode should be used when running a PyLoN-IR detector via WinSpec. Do not select Safe Mode if the choice is available. LightField always uses Fast Mode.

Figure 8-8 shows a flow chart for Fast Mode operation.

Figure 8-8: Fast Mode Operation Flowchart

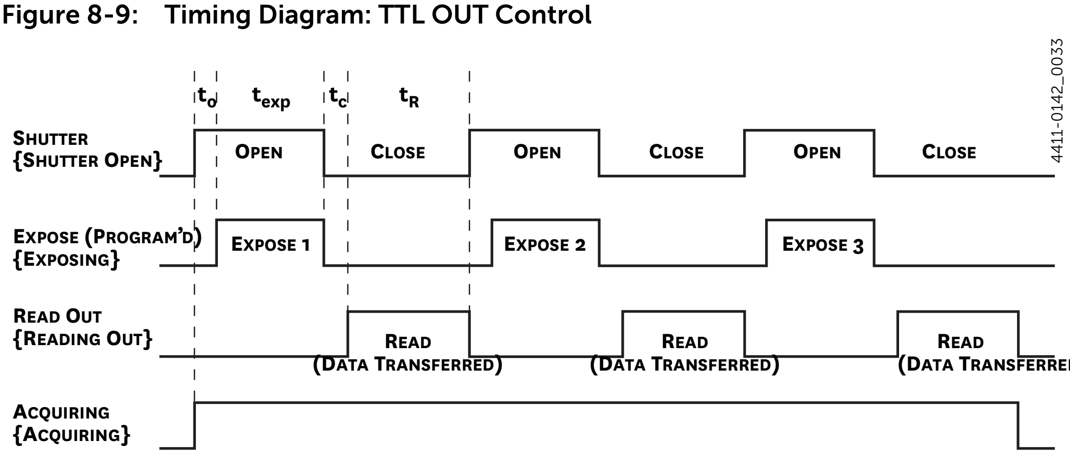


8.4 TTL OUT Control

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

- 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.
- Expose (Program'd) {Exposing}
  This level is at a logic high during the programmed exposure time (i.e., the time configured in the software.) It can be used to synchronize a pulser or timing generator with exposure.
- Read Out {Reading Out}
  It is at a logic high when CCD is being read; otherwise low.
- 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. The timing diagram in Figure 8-9 assumes three frames have been programmed.

Figure 8-9: Timing Diagram: TTL OUT Control



Additional related signals and configuration settings include:

- Logic 1 {Always High}

  The level at the connector is high.
- 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 from the TRIGGER IN signal before exposing the CCD. The level goes low when a trigger is detected and exposure begins. The Wait for Trigger (WFT) signal goes high immediately after readout or, if it is active, after Pre Open {Open Before Trigger}.

  If continuous cleans is enabled, the camera checks for a trigger on TRIGGER IN before initiating a continuous clean cycle. If no trigger has occurred, a cleaning cycle is initiated and completed.

  Before the next cycle begins, TRIGGER IN is checked again, and exposure will start if a trigger has occurred.

NOTE:

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

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Chapter 9: Troubleshooting

WARNING!
Do not attach or remove any cables while the PyLoN-IR system is powered on.

Recommended troubleshooting procedures are available for many issues that may occur while working with a PyLoN-IR system. Refer to Table 9-1 for additional information.

Table 9-1: Issues with Recommended Troubleshooting Procedures

Issue	Refer to...
Baseline Signal Suddenly Changes	page 78
Camera1 (or Similar Name) in Camera Name Field	page 78
Temperature Lock Cannot be Achieved/Maintained	page 80
Detector Loses Temperature Lock	page 80
Gradual Deterioration of Cooling Capability	page 80
Data Overrun Due to Hardware Conflict	page 81
Program Error	page 82
Serial Violations Have Occurred. Check Interface Cable.	page 83
Detector Stops Working	page 84
Ethernet Network Is Not Accessible	page 84
Vignetting	page 86

9.1 Baseline Signal Suddenly Changes

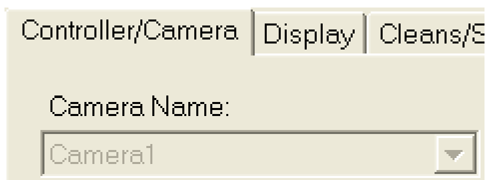
There are two possible reasons for this change:

- The temperature, gain, or speed setting has been changed. In this case, a change in baseline signal is normal.
- There may be excessive humidity in the detector vacuum enclosure of the camera. If the temperature setting has not been changed and you observe a baseline signal change, turn off the system immediately and, if relevant, remove all liquid nitrogen from the detector. An excess humidity condition should be corrected promptly or permanent damage not covered by the Warranty could occur. Have the unit serviced by Teledyne Princeton Instruments or an authorized service facility of Teledyne Princeton Instruments. Refer to Contact Information on page 110 for complete contact information.

9.2 Camera1 (or Similar Name) in Camera Name Field

When the Camera Detection Wizard installs a new camera, the camera is automatically named “Camera#” (where # = 1, 2, or 3, depending on the number of cameras detected) This name will appear in the Hardware Setup title bar and as the active camera on the Hardware Setup ► Controller/Camera tab. See Figure 9-1

Figure 9-1: Camera1 in Camera Name Field

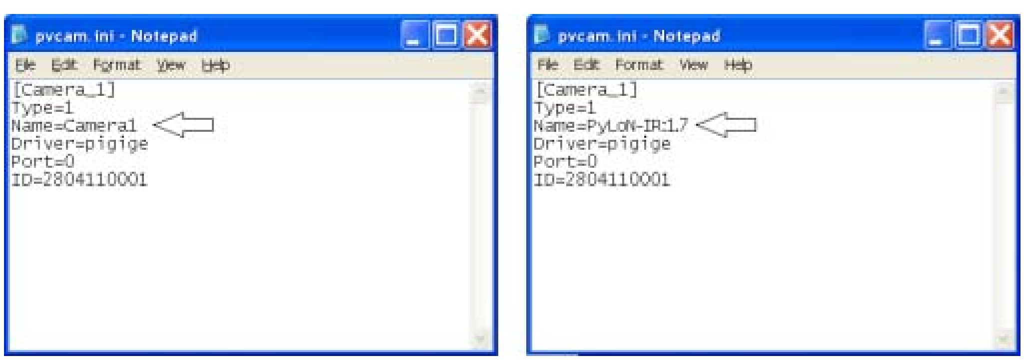


If desired, a more specific name may be assigned to the camera by editing `PVCAM.INI` (located in the Windows directory.) The new name will then be used by the system until the Camera Detection Wizard is run again.

Perform the following procedure to change the default Camera Name:

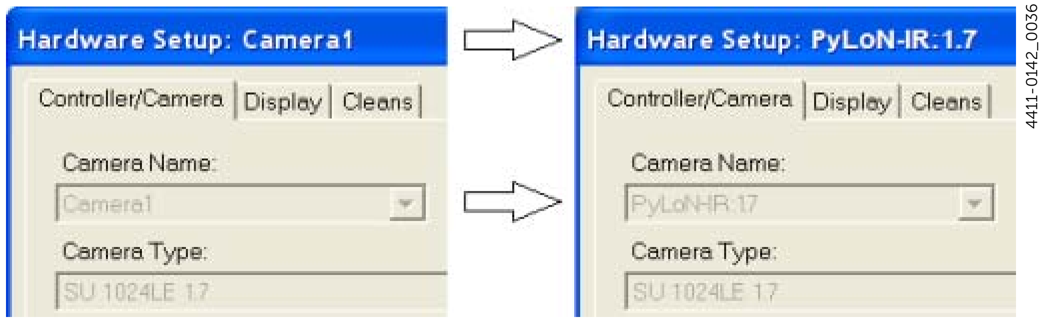
1. Close the application program if it is running.
2. Using `Notepad.exe`, open `PVCAM.INI` from the Windows directory.
3. Edit the Name as shown in Figure 9-2.

Figure 9-2: Editing Camera Name in Notepad



4. Save the edited file.
5. The next time WinSpec/32 is launched, the new name will be displayed on the Hardware Setup dialog. See Figure 9-3.

Figure 9-3: Edited Camera Name in Hardware Setup Dialog



NOTE:

If the Camera Detection Wizard is launched and run at a later time, the name will be revert back to the default name (i.e., Camera1.)

9.3 Cooling Troubleshooting

This section provides recommended troubleshooting guidelines for cooling-related problems.

9.3.1 Temperature Lock Cannot be Achieved/Maintained

Possible causes include:

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

9.3.2 Detector Loses Temperature Lock

The internal temperature of the detector is too high which be a result of:

- The operating environment being particularly warm;
- Attempting to operate at a temperature colder or warmer than the specified limit;
- Insufficient liquid nitrogen in the Dewar. Refill the Dewar and verify that temperature lock can now be achieved.

If the problem persists, contact Teledyne Princeton Instruments' Customer Support. Refer to Contact Information on page 110 for complete contact information.

9.3.3 Gradual Deterioration of Cooling Capability

With time, there will be a gradual deterioration of the detector'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 array detectors 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 detectors will be faster than in old ones. When the detector no longer maintains an acceptable cold temperature, contact the factory Customer Support to make arrangements for returning the detector to have the vacuum restored. Refer to Contact Information on page 110 for complete contact information.

WARNING!

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

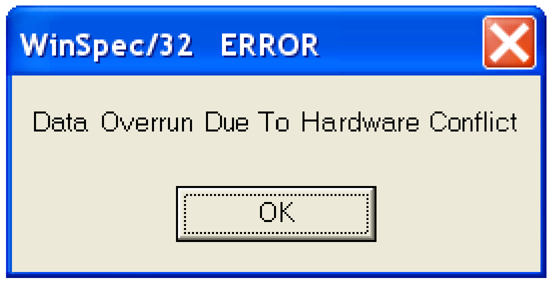
9.4 Error Messages

This section provides information about troubleshooting error messages that may be displayed.

9.4.1 Data Overrun Due to Hardware Conflict

Figure 9-4 illustrates the dialog that may appear when acquiring a test image, acquiring data, or running in focus mode. If it is displayed, check the array size and then check the DMA buffer size. A large array (e.g., a 2048x2048 array,) requires a larger DMA buffer larger setting than that for a smaller array (e.g., a 512x512 array.)

Figure 9-4: Data Overrun Due to Hardware Conflict Dialog



Perform the following procedure to change the DMA buffer size:

1. Note the array size listed on the Setup ► Hardware ► Controller/CCD tab or on the Acquisition ► Experiment Setup ► Main tab Full Chip dimensions.
2. Open the Setup ► Environment ► Environment dialog.
3. Increase the DMA buffer size to a minimum of 32 MB (64 MB if it is currently 32 MB or 128 MB if it is currently 64 MB), click on OK, and close WinSpec.
4. Reboot the computer.
5. Restart the application software, and begin acquiring data or focusing. If the problem persists, increase the DMA buffer size again.

9.4.2 Program Error

Figure 9-5 illustrates the dialog that may be displayed when attempting to acquire a test image, acquire data, or run in focusing mode and the DMA buffer size is too small. A large array (e.g., a 2048x2048 array,) requires a larger setting than that for a smaller array (e.g., a 512x512 array.)

Figure 9-5: Typical Program Error Dialog

4411-0142_0038

Perform the following procedure to correct the problem:

1. Click on OK.
2. Reboot WinSpec.
3. Note the array size on the Setup ► Hardware ► Controller/CCD tab or on the Acquisition ► Experiment Setup ► Main tab Full Chip dimensions). If the detector contains a large array (e.g., a 2048x2048 array,) and the DMA buffer size is too small, there will not be enough space in memory for the data set.
4. Open Setup ► Environment ► Environment dialog.
5. Increase the DMA buffer size to a minimum of 32 MB (64 MB if it is currently 32 MB, or 128 MB if it is currently 64 MB,) click on OK, and close WinSpec.
6. Reboot the computer.
7. Restart WinSpec and begin acquiring data or focusing. If the problem persists, increase the DMA buffer size again.

9.4.3 Serial Violations Have Occurred. Check Interface Cable.

Figure 9-6 illustrates the error message displayed when acquiring an image or focusing the detector and one (or both) of the following conditions exists:

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

Figure 9-6: Serial Violations Have Occurred Dialog

4411-0142_0039

Perform the following procedure to correct the problem:

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

NOTE:

This error message will also be displayed if the detector system is turned OFF or a cable comes loose while the application software is running in Focus mode.

9.5 Detector 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 detector system hardware, begin with these simple checks:

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

9.6 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 this 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 you are using WinSpec/32 (32-bit) or LightField (64-bit).

9.6.1 WinSpec/32 Applications

Perform the following procedure to restore an Ethernet network connection for WinSpec/32 applications:

1. Navigate to the directory in which the EbDriverTool32.exe is stored.

   NOTE:

   The file may also be named EbDriverTool.exe.

   The file is typically stored on the host computer within the default Pleora directory (or one of the subdirectories):

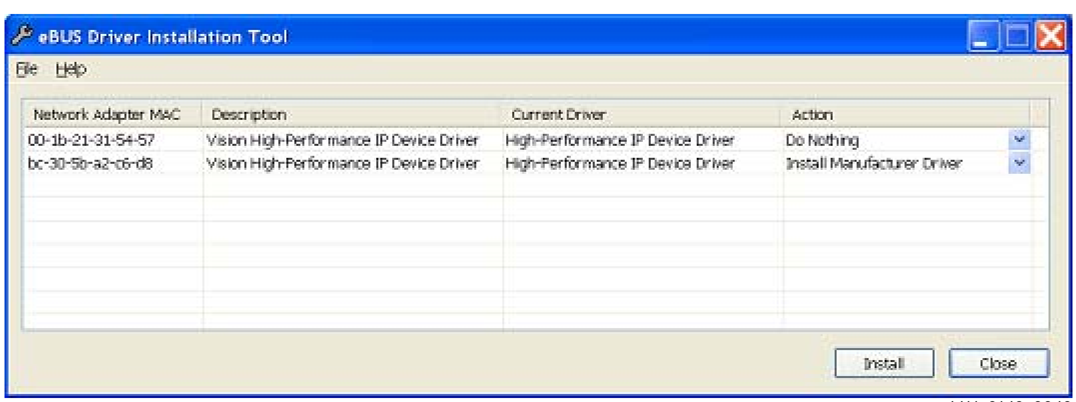
   `C:\Program Files\Common Files\Pleora`

   If the file cannot be located on the host computer, it may be downloaded from the following location:

   ftp://ftp.princetoninstruments.com/public/Software/Official/WinX32/GigE/

2. Double click on the file to launch the application. Figure 9-7 illustrates the installation tool dialog that is displayed.

Figure 9-7: Typical 32-Bit eBus Driver Installation Tool Dialog



4411-0142_0040

3. Review the list of Ethernet cards displayed. Select the desired Ethernet card, and within the Action column, select Install Manufacturer Driver from the pull-down menu.
4. Click on the Install button to initiate the installation of the appropriate driver.
5. Once the driver installation has been completed, it may be necessary to reboot the computer.

   If prompted for a reboot, select:
   - Yes to reboot the host computer immediately, or
   - NO to delay rebooting the computer until a later time.

     When delaying the reboot, dismiss/close the eBUS Driver Installation Tool dialog.
6. Once the computer has been rebooted, verify that the network connection has been established.

9.6.2 LightField Applications

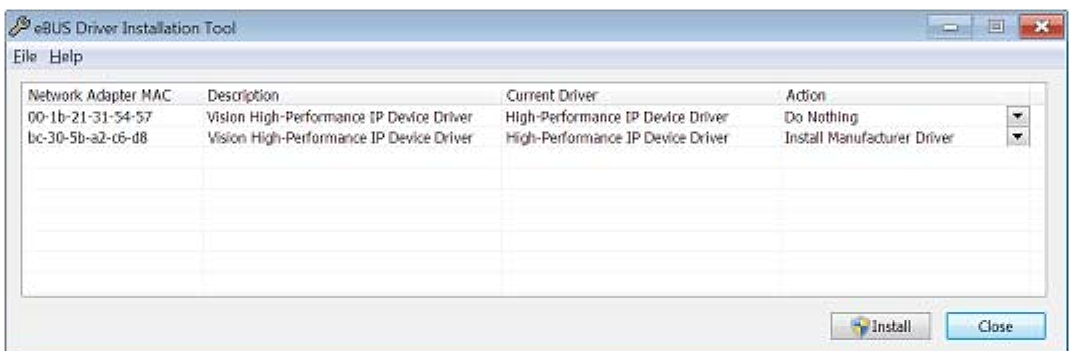
Perform the following procedure to restore an Ethernet network connection for LightField applications:

1. Navigate to the directory in which the EbDriverTool64.exe is stored.

   The file is typically stored on the host computer within the default Pleora directory (or one of the subdirectories):

   `C:\Program Files\Common Files\Pleora`
2. Double click on the file to launch the application. Figure 9-8 illustrates the installation tool dialog that is displayed.

Figure 9-8: Typical 64-Bit eBUS Driver Installation Tool Dialog



4411-0142_0041

3. Review the list of Ethernet cards displayed. Select the desired Ethernet card, and within the Action column, select Install Manufacturer Driver from the pull-down menu.
4. Click on the Install button to initiate the installation of the appropriate driver.
5. Once the driver installation has been completed, it may be necessary to reboot the computer.

   If prompted for a reboot, select:
   - Yes to reboot the host computer immediately, or
   - NO to delay rebooting the computer until a later time.

     When delaying the reboot, dismiss/close the eBUS Driver Installation Tool dialog.
6. Once the computer has been rebooted, verify that the network connection has been established.

9.7 Vignetting

All arrays have been tested for uniformity and do not exhibit any vignetting (i.e., reduction of response,) at the extreme ends of the array. If such a reduction in response across the array is measured, 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 have been designed to allow light rays to enter through the Dewar window even at very wide angles (e.g., $\geq$ 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.

Appendix A: Technical Specifications

CAUTION!

The specifications supplied in this manual are subject to change without notification. For up-to-date information about PyLoN-IR detectors, refer to the data sheets available from Teledyne Princeton Instruments at www.princetoninstruments.com or contact a Teledyne Princeton Instruments Customer Representative. Refer to Contact Information on page 110 for additional information.

A.1 Mechanical Dimensions

Refer to Appendix B, Outline Drawings, on page 95 for hardware dimensions.

Power supply weight: 13 lb [5.9 kg]

A.2 Photo Diode Array Specifications

Contact the factory for up-to-date information about available chips and chip performance specifications, or visit www.princetoninstruments.com for the current list of arrays supported by PyLoN-IR.

A.3 Focal Plane Distance

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

Table A-1: Typical Focal Plane Distances

Cooling	Reference Points	Distance
LN	Front of Non-Shutter Housing[a] to Focal Plane	0.549 ± 0.01″

a. The housing for a detector has a 3.60″ bolt circle.

A.4 Power Specifications

All DC voltages required by PyLoN-IR cameras are generated by an external power supply and supplied to the camera using a custom power cable.

Refer to Table A-2 for input power specifications for the external PyLoN-IR Power Supply.

Table A-2: Input Power Specifications: External PyLoN-IR Power Supply

Parameter	Specification			Unit
	Minimum	Nominal	Maximum	
Input Voltage	96	100 120 220 240	264	V_{AC}
Input Frequency	47	50 60	63	Hz
Input Power	—	—	100	W

A.5 Environmental Specifications

Refer to Table A-3 for environmental specifications for the PyLoN-IR system.

Table A-3: PyLoN-IR Environmental Specifications

Parameter	Specification		
	Minimum	Nominal	Maximum
Storage Temperature	-20°C	—	+55°C
Operating Temperature	5ºC	—	+30ºC
Operating Ambient Relative Humidity	<50% (non-condensing)		
Operating Ambient Temperature[a]	0°C	—	+30°C

a. Although operation to -25°C is achievable, operation below 0°C is not guaranteed.

CAUTION!

High humidity climates may require the continuous flushing of the spectrograph’s exit port with nitrogen. If LN-cooled detectors are operated under high humidity conditions, ice buildup could occur around the pressure relief vent valve ports and prevent them from operating properly. Because the venting safety bell covers the valves, this condition would not be readily apparent. Damage from humid condensation may not be covered by the product warranty.

A.5.1 Detector Ventilation

Allow a minimum of one inch clearance for side and rear air vents. When the detector is placed inside an enclosure, > 30 cfm air circulation and heat dissipation of 50 W is required.

A.6 AUX I/O Interface

The AUX I/O interface provides access to the trigger function, DAC, and TTL signals via a rear panel connector and an AUX I/O cable that is supplied with each PyLoN-IR system. This section provides pinout information for both the rear panel AUX I/O connector as well as the AUX I/O Cable.

Table A-4 provides TTL signal-specifications for the AUX I/O interface.

Table A-4: AUX I/O Interface TTL Signal Specifications

Parameter	Specification			Unit
	Minimum	Nominal	Maximum	
V_{IN} (logic 1)	2.4	—	—	V_{DC}
V_{IN} (logic 0)	—	—	0.9	V_{DC}
Rise Time			?40	ns
Duration	?100			ns

The AUX I/O connector is located on the rear of the PyLoN-IR chassis. It is a female, DB26, high-density connector.

Figure A-1 illustrates the pinout of the AUX I/O connector, viewed from the rear panel of the PyLoN-IR chassis, with each contact/pin identified by its pin number.

Figure A-1: AUX I/O Connector Pinout

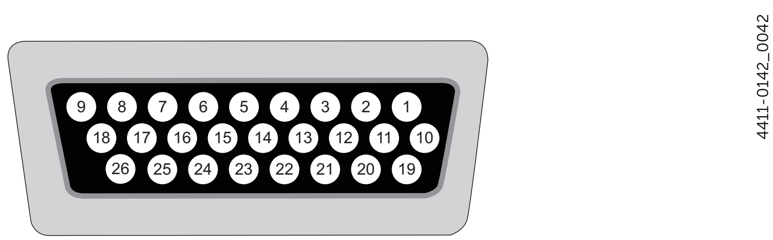


Table A-5 provides complete information about each AUX I/O pin and signal sorted by pin number.

Table A-5: AUX I/O Connector Pinout and Signal Descriptions (Sheet 1 of 3)

Pin #	Signal Name	Signal Description
1	TRIGGER IN	0 to +3.3V 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.

Table A-5: AUX I/O Connector Pinout and Signal Descriptions (Sheet 2 of 3)

Pin #	Signal Name	Signal Description
4	DAC1	10-bit programmable output (0 – 2.5 V). 100 ? source impedance.
5	DAC2	10-bit programmable output (0 – 2.5 V). 100 ? 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 read out of the array.
8	EXPOSE MON	Active high. A high level on this output indicates that the detector 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).
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).

Table A-5: AUX I/O Connector Pinout and Signal Descriptions (Sheet 3 of 3)

Pin #	Signal Name	Signal Description
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 detector 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	Reserved for Future Use: DO NOT USE
22	Reserved	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.

A.6.1 AUX I/O Cable

Each PyLoN-IR system includes an AUX I/O cable that provides convenient access to several system signals. The AUX I/O interface cable is comprised of a male DB26 connector on one end, and five female BNC cables on the other end, each of which provides access to a system signal.

Figure A-2 illustrates a typical cable.

Figure A-2: AUX I/O Cable (6050-0681)

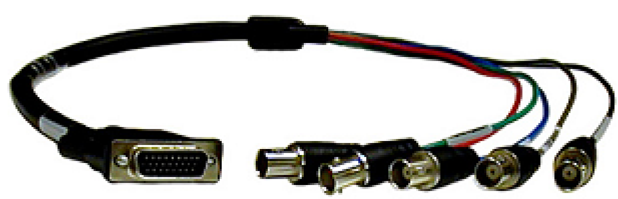


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Table A-6 provides the color code and pinout information for the AUX I/O interface cable.

Table A-6: AUX I/O Interface Cable Pinout and Signal Information (Sheet 1 of 2)

Cable Color	BNC Conductor	Signal Name	DB26 Pin #
Red	Center	TRIGGER IN	1
	Shield	Ground	3

Table A-6: AUX I/O Interface Cable Pinout and Signal Information (Sheet 2 of 2)

Cable Color	BNC Conductor	Signal Name	DB26 Pin #
Green	Center	TTL OUT	2
	Shield	Ground	6
Blue	Center	READOUT MON	7
	Shield	Ground	18
Gray	Center	EXPOSE MON	8
	Shield	Ground	20
Black	Center	SHUTTER MON	23
	Shield	Ground	25

A.7 Quantum Efficiency

The Quantum Efficiency for PyLoN-IR cameras varies with respect to the ambient temperature at which it is operating.

Figure A-3 shows the relative QE variation with temperature for 1.7 μm cameras while Figure A-4 shows the relative variation with temperature for 2.2 μm cameras.

Figure A-3: Relative QE vs. Temperature for PyLoN-IR 1.7 μm Cameras

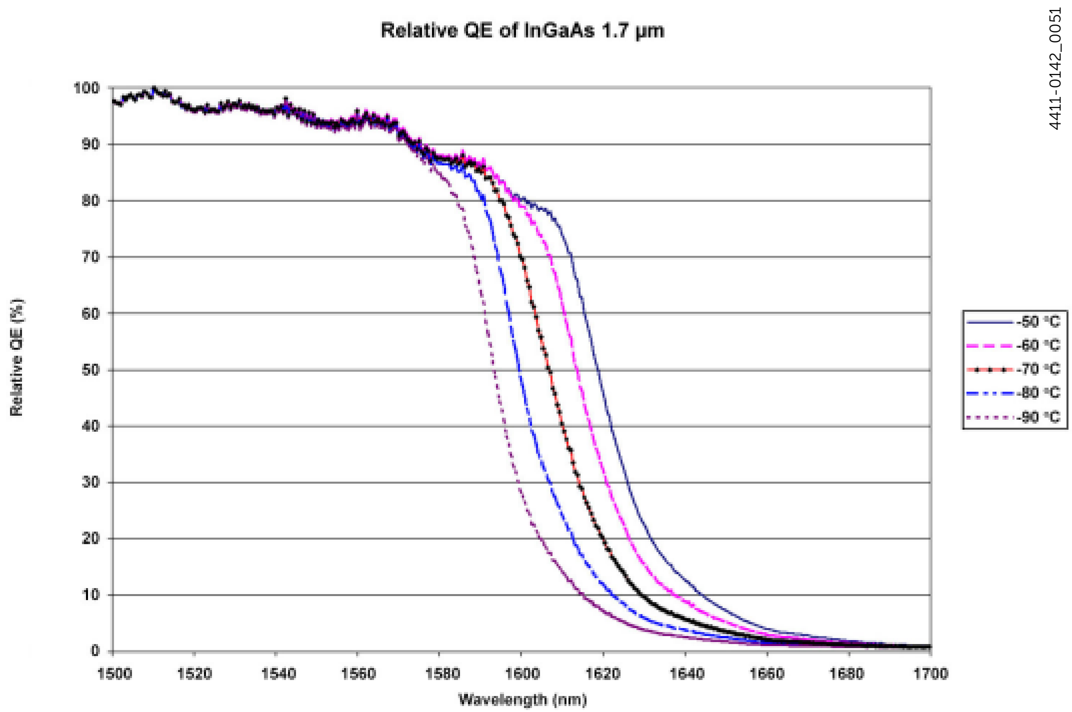
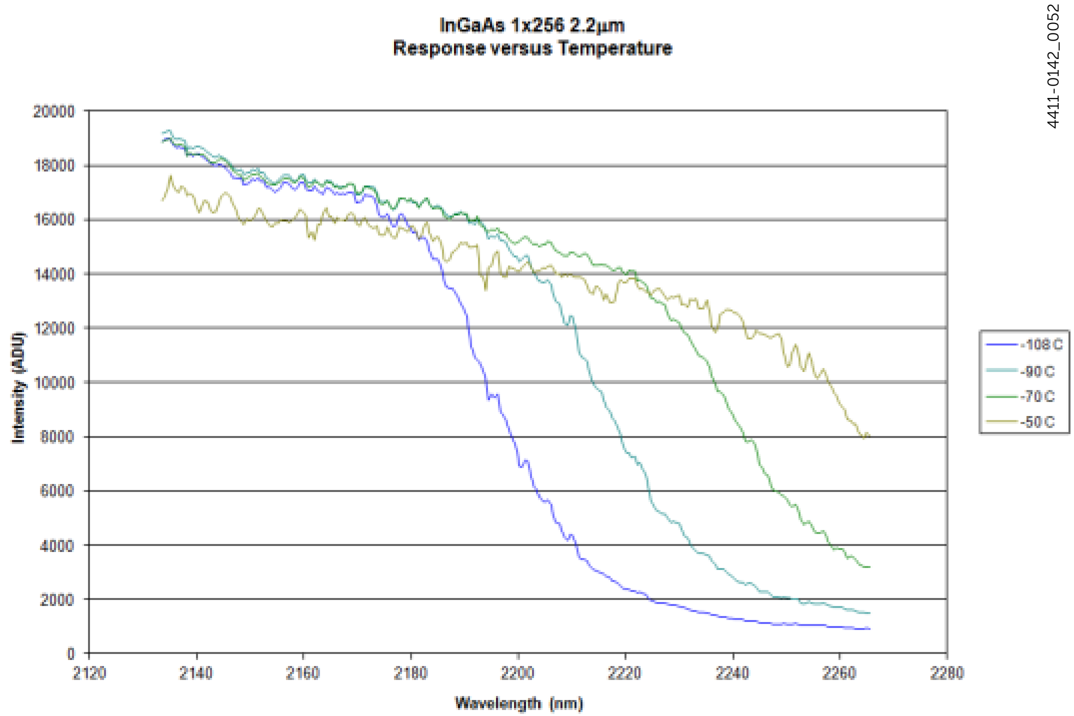


Figure A-4: Relative QE vs. Temperature for PyLoN-IR 2.2 µm Cameras



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Appendix B: Outline Drawings

NOTE:

Dimensions are in inches unless otherwise indicated.

Figure B-1: Outline Drawing: PyLoN-IR, Side-On Dewar, Flange-Mount

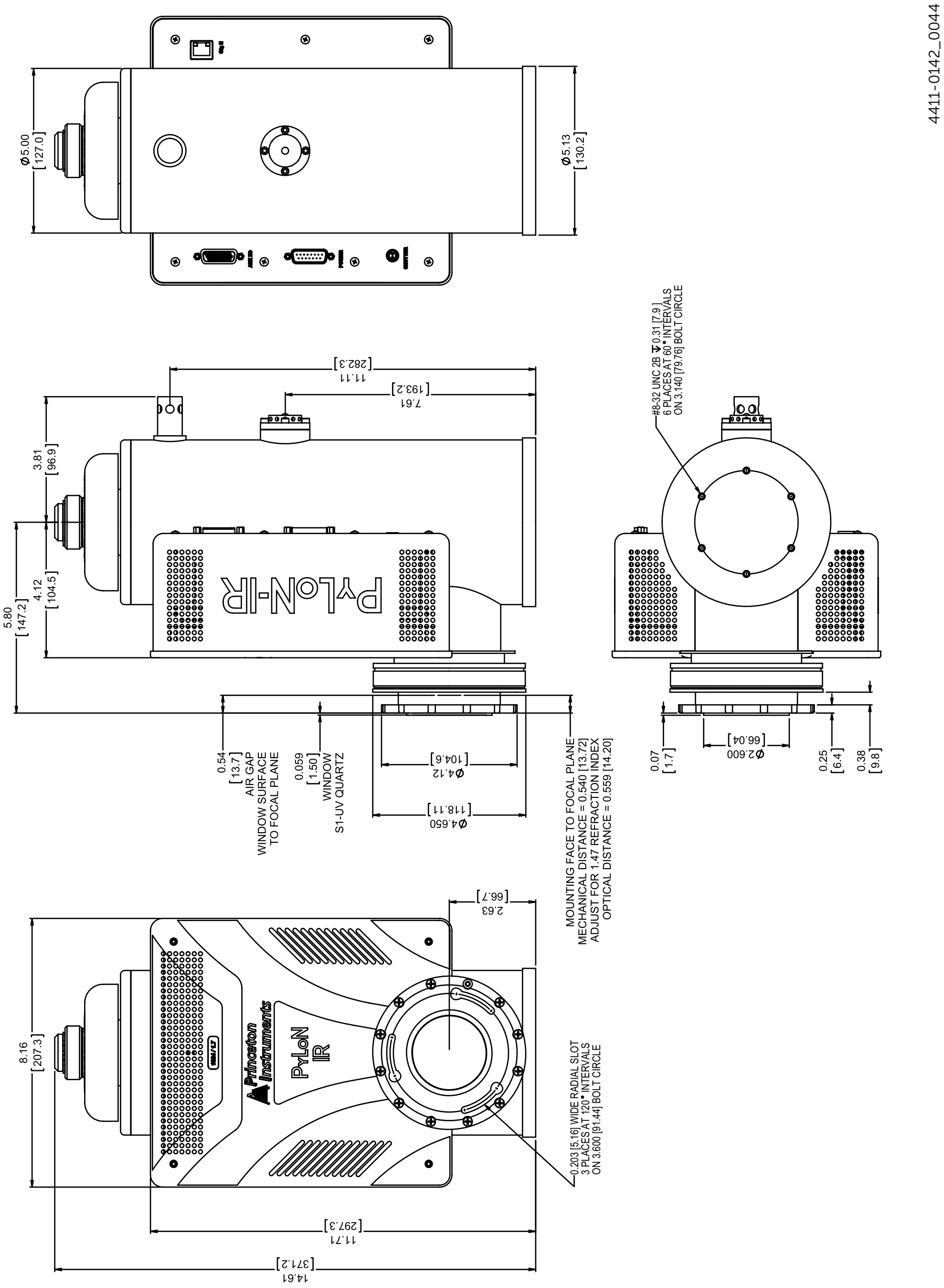
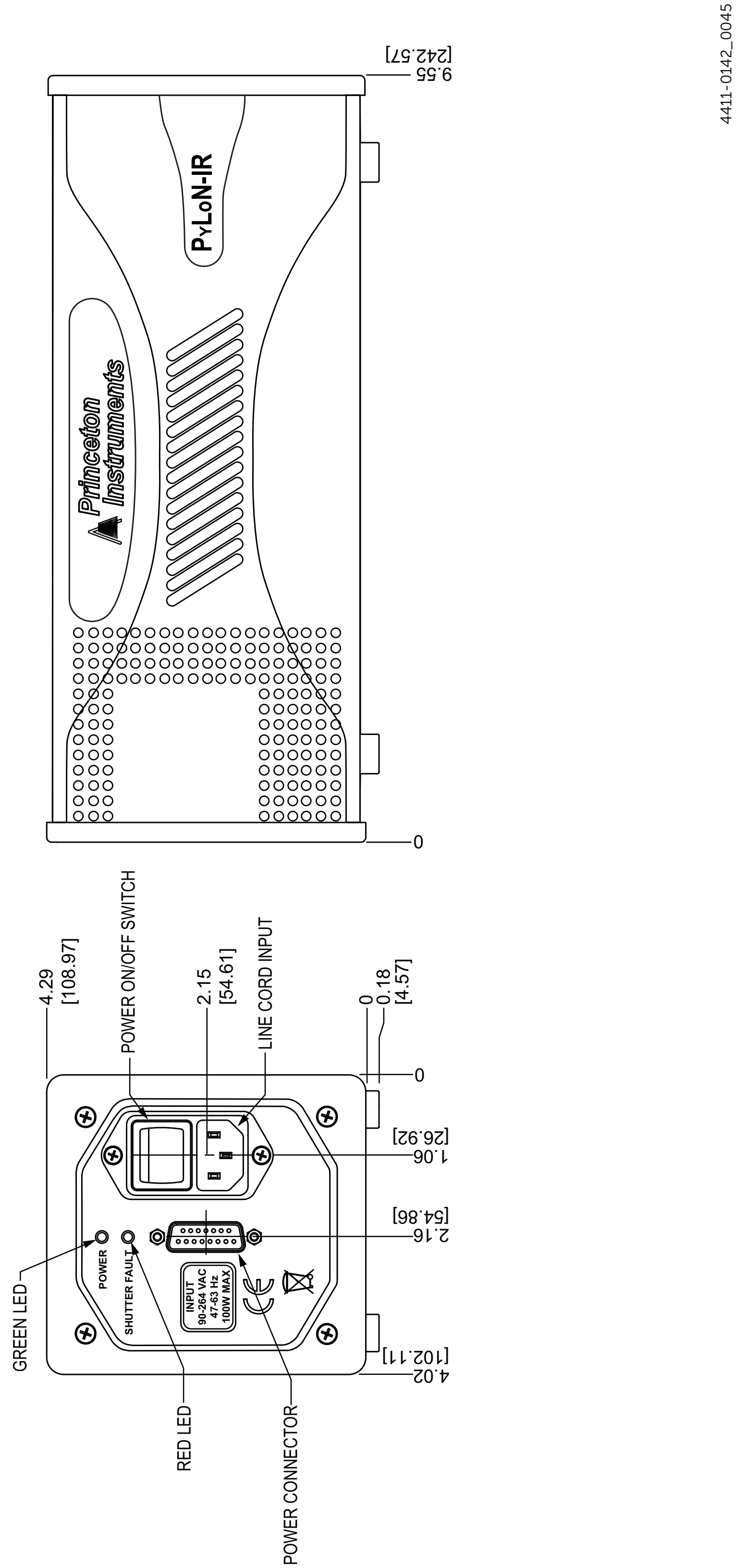


Figure B-2: Outline Drawing: PyLoN-IR Power Supply



Appendix C: Spectrograph Adapters

Teledyne Princeton Instruments offers a flange-mount adapter for PyLoN-IR systems to accommodate Teledyne Acton Research SpectraPro Series spectrograph sliding tubes.

Figure C-1 illustrates the SpectraPro Series flange-mount adapter.

Figure C-1: Teledyne Acton Research SpectraPro Series Flange-Mount Adapter Mounting Diagram

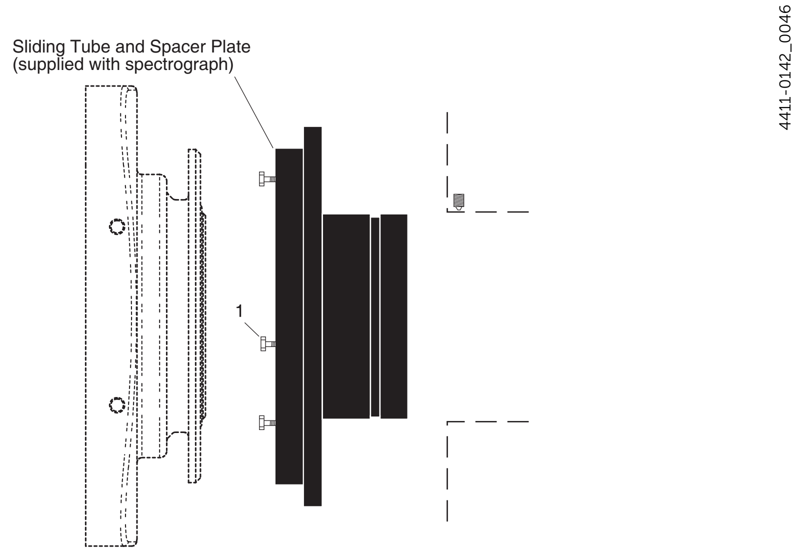


Table C-1 provides a list of hardware required to mount an Teledyne Acton Research SpectraPro Series Flange-Mount Adapter.

Table C-1: Required Hardware: Flange-Mount to Teledyne Acton Research SpectraPro Series Spectroscopy-Mount

Qty	P/N	Description
3	2826-0120	Screw, 10-32 x ½, Hex Head, Stainless Steel

Perform the following procedure to install this adapter onto the PyLoN-IR camera:

1. Verify the shipping cover has been removed from the detector port on the spectrograph.
2. Loosen the two setscrews holding the sliding tube in the spectrograph.
3. Rotate the sliding tube as you remove it from the spectrograph.
4. If the spacer plate has been removed, reinstall it on the adapter.
5. Leaving ¼” of thread exposed, mount the three (3) hex head screws to the adapter.
6. Mount the adapter to the flange and rotate the adapter so that the baffle is aligned with the array. The screw heads should be over the narrow section of the slots.

7. Tighten the screws.
8. Rotate the sliding tube as you gently insert it into the spectrograph.
9. Secure the sliding tube with the setscrews.

NOTE:

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

Appendix D: Calibration Charts

This appendix provides the following calibration charts for use with the PyLoN-IR camera:

- HG Calibration Spectrum for PyLoN-IR;
- Ne-Ar Calibration Spectrum for PyLoN-IR.

Figure D-1: Hg Spectrum: PyLoN-IR 1.7/SP-2500

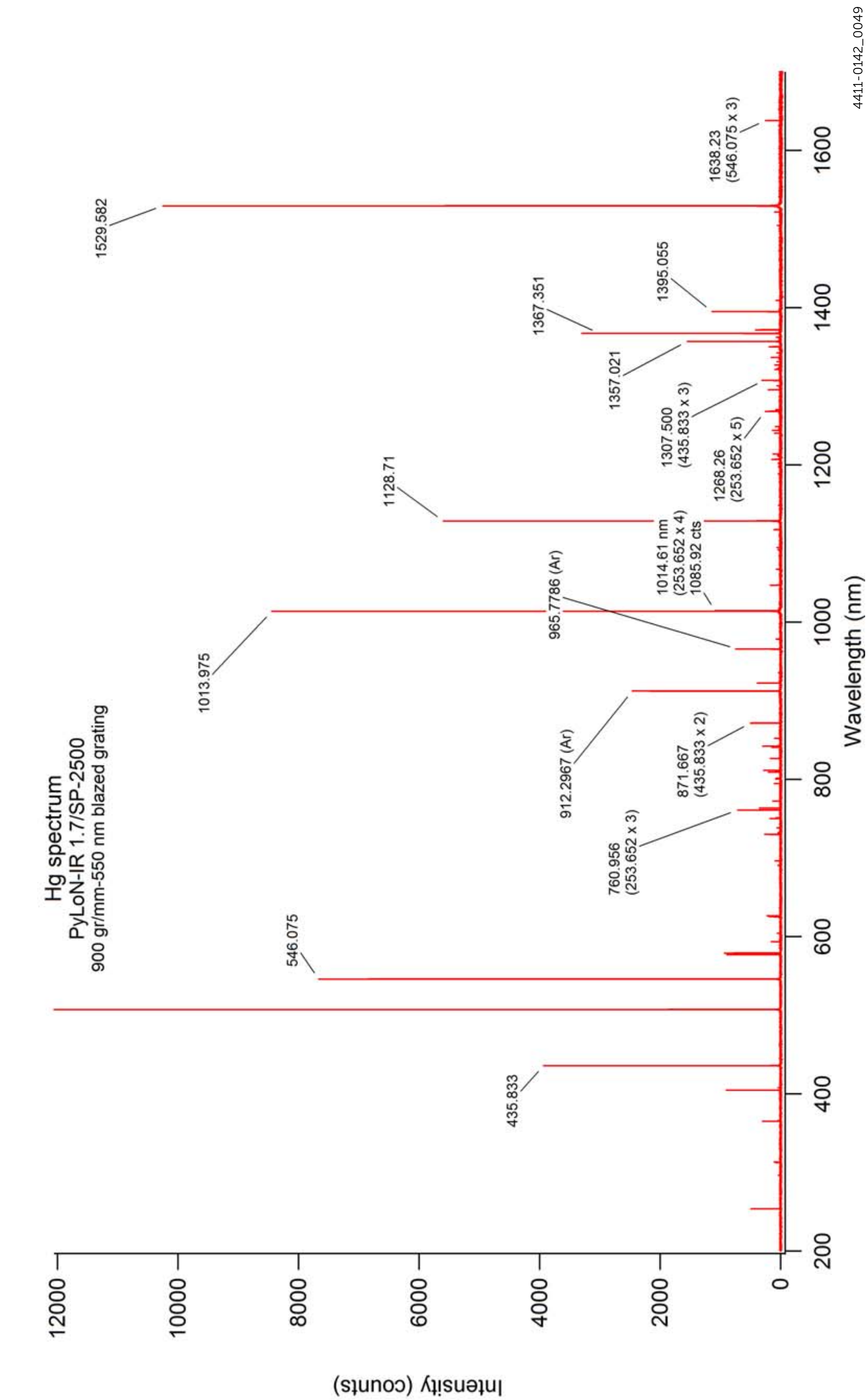
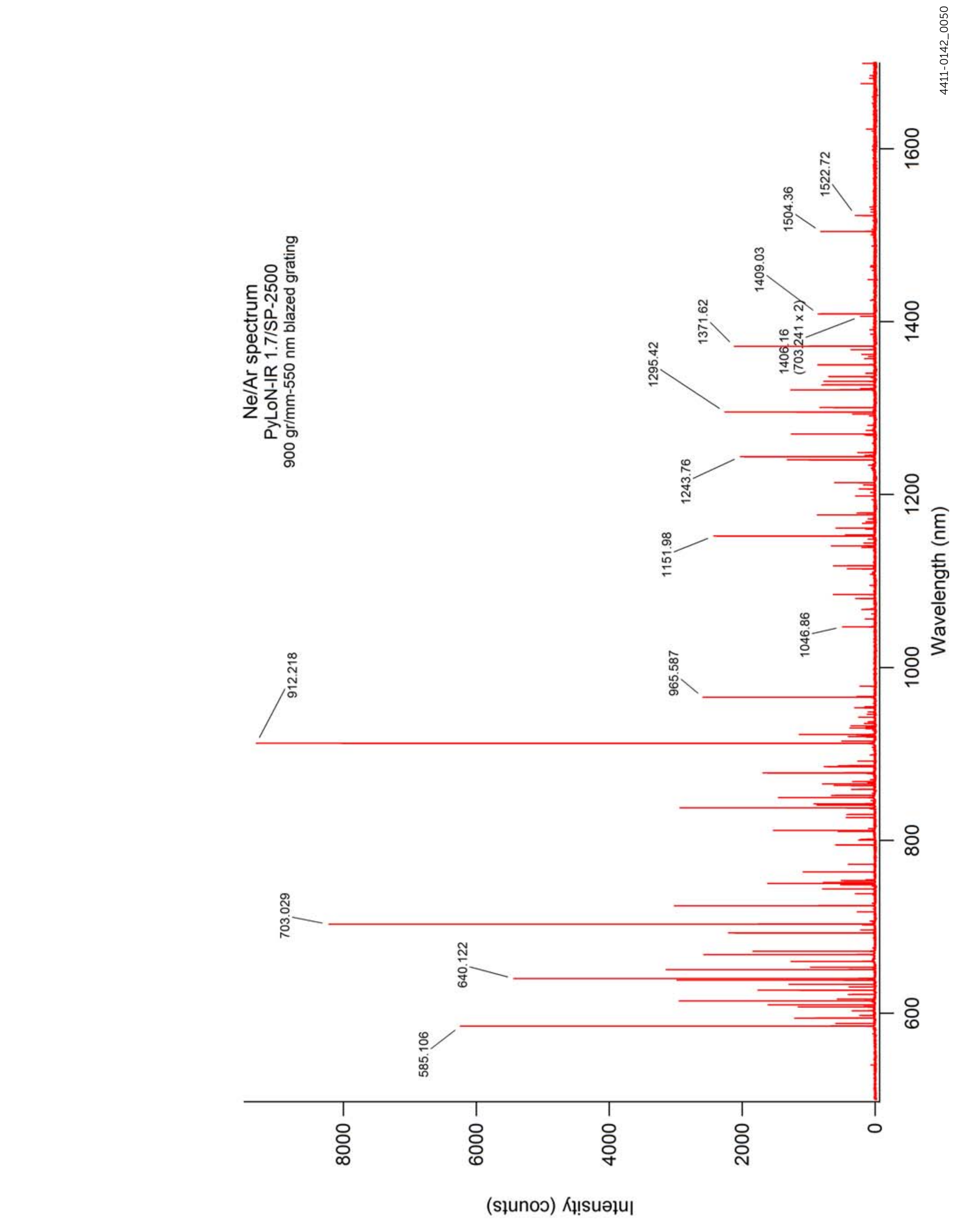


Figure D-2: Ne/Ar Spectrum: PyLoN-IR 1.7/SP-2500



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Appendix E: WinSpec/32/LightField Cross Reference

This appendix provides cross reference information for terminology used within the WinSpec/32 and LightField application software packages.

E.1 WinSpec/32-to-LightField Terminology

Refer to Table E-1 for a list of WinSpec/32 terms and their corresponding LightField terms.

Table E-1: WinSpec/32-to-LightField Cross Reference (Sheet 1 of 2)

WinSpec/32 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 E-1: WinSpec/32-to-LightField Cross Reference (Sheet 2 of 2)

WinSpec/32 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

E.2 LightField to WinSpec/32

Refer to Table E-2 for a list of LightField terms and their corresponding WinSpec/32 terms.

Table E-2: LightField-to-WinSpec/32 Cross Reference (Sheet 1 of 2)

LightField Term	WinSpec/32 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 E-2: LightField-to-WinSpec/32 Cross Reference (Sheet 2 of 2)

LightField Term	WinSpec/32 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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