



VersArray[®] System



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3660 Quakerbridge Rd
Trenton, NJ 08619
TEL: 800-874-9789 / 609-587-9797
FAX: 609-587-1970

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Introduction

VersArray® Family of Cameras

The VersArray CCD cameras are high-performance digital systems designed for demanding low-light applications. The line incorporates a wide selection of full-frame, front- or back-illuminated, scientific-grade CCDs, a choice of thermoelectric or cryogenic cooling, and low-noise electronics to provide high sensitivity and high dynamic range. Permanent coatings are available to extend the range of the cameras into the UV while maintaining high quantum efficiency. The VersArray cameras are therefore ideal for a wide variety of demanding applications, including high-throughput screening, streak tube readout, gel documentation, astronomy, pressure-sensitive paint imaging, and semiconductor failure analysis.



Complete Camera Control

The operation of the VersArray camera is regulated by the camera controller. This electronics box contains the circuitry required to accept input from the host computer and software and convert it to appropriate control signals for the camera. These signals include extensive capabilities for synchronizing the operation of the VersArray system with the rest of your experiment. Because all the sensitive electronic circuits are enclosed in the EM-shielded controller, the system is able to deliver the lowest noise performance, even in a less-than-optimal environment. The controller unit also collects the analog signal returned by the camera, digitizes it, and sends it to the computer. Power supplies for the camera, along with temperature-regulation circuits, are also contained in the controller.

The controller allows you to specify read rate, on-chip binning parameters ($m \times n$), and regions of interest — all under software control. For instance, if your experiment requires rapid image acquisition, then the CCD's on-chip binning can be set to increase frame rates. For the utmost in versatility, the VersArray controller can be configured with a dual-speed digitizer that provides fast imaging rates and low-noise readout modes.

System Components

Standard Components

A VersArray system consists of the camera, an ST-133 controller, the appropriate interface hardware for your computer system, and this user manual. Note that an internal shutter is standard with the thermoelectric and cryogenic (LN-cooled) cameras.



Figure 1. Standard Components

Optional System Components

Optional items include the WinView/32 application software, mounting adapters, coolant circulators, and dual digitization capability.

Application Software

The VersArray camera can be operated by using WinView/32, Princeton Instrument's 32-bit Windows® software package designed specifically for high-end imaging or by using other commercially available image processing packages. WinView/32 provides comprehensive image capture and display functions, so you can perform data acquisition without having to rely on third-party software. The package also facilitates snap-ins to permit easy customization of any function or sequence. Using the built-in macro record function, you can also create and edit your own macros to automate a variety of operations. WinView takes full advantage of the versatility of the VersArray camera and even enhances it by making integration of the detection system into larger experiments or instruments an easy, straightforward endeavor.

Note: WinView/32 (version 2.5+) supports Programmable Virtual Camera Access Method (PVCAM®), a library of functions that can be used to control and acquire data. Image processing must be provided via custom code or by extensions to other commercially available image processing packages.

About this Manual

Manual Organization

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

Notes:

1. The general identifier "ST-133" is used for both the ST-133A Controller and the ST-133B Controller. Where there is a difference, the specific identifier is used.
2. "WinX" is a generic term for WinView, WinSpec, and WinXTest application software.

Chapter 1, Introduction provides an overview of the VersArray cameras.

Chapter 2, System Component Descriptions provides information about the camera, controller, interface card, cables and application software.

Chapter 3, Installation Overview cross-references system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.

Chapter 4, System Setup provides detailed directions for setting up the camera for imaging, spectroscopic, or microscopy applications and presents over-exposure protection considerations.

Chapter 5, Operation discusses a number of topics, including cooling and effects of high humidity and includes a step-by-step procedure for verifying system operation.

Chapter 6, Advanced Topics discusses standard timing modes (Free Run, External Sync, and Continuous Cleans), Fast and Safe speed modes, TTL control, and Kinetics mode.

Chapter 7, Troubleshooting provides courses of action to take if you should have problems with your system.

Appendix A, Specifications includes camera and controller specifications.

Appendix B, Outline Drawings includes outline drawings of the VersArray® cameras and the ST-133A and ST-133B Controllers.

Appendix C, Adapter Focusing Procedures discuss focusing of an F-mount adapter and focusing of F-mount and C-mount lenses

Appendix D, Spectrometer Adapters provides mounting instructions for the spectrometer adapters available for VersArray LN and NTE cameras.

Appendix E, USB 2.0 Limitations covers the currently known limitations associated with operating under the USB 2.0 interface.

Declarations of Conformity contains the Declarations of Conformity for VersArray systems (LN-, NTE-, and TEA-cooled).

Warranty & Service contains the warranty and customer support contact information.

Safety Related Symbols Used in this Manual



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



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

Grounding and Safety

The ST-133 is of Class I category as defined in IEC Publication 348 (Safety Requirements for Electronic Measuring Apparatus). It is designed for indoor operation only. Before turning on the controller, the ground prong of the powercord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong, or must be properly connected to an adapter that complies with these safety requirements.

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

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

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

Precautions

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

- Always switch off and unplug the ST-133 Controller before changing your system configuration in any way.
- The CCD array is very sensitive to static electricity. Touching the CCD can destroy it. Operations requiring contact with the device can only be performed at the factory.
- If you are using high-voltage equipment (such as an arc lamp) with your camera system, be sure to turn the controller power ON LAST and turn the controller power OFF FIRST.
- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. The CCD can be permanently damaged by transient voltage spikes. If electrically noisy devices are present, an isolated, conditioned power line or dedicated isolation transformer is highly recommended.
- Never connect or disconnect any cable while the system is powered on. Reconnecting a charged cable may damage the CCD.
- Never prevent the free flow of air through the equipment by blocking the air vents.
- Never operate a liquid-assisted or liquid-cooled-only VersArray camera with coolant at a temperature below that specified for it.

UV Effect on Scintillator

Caution

If you have a camera with a UV scintillator (lumogen) coated CCD, protect it from unnecessary exposure to UV radiation. This radiation slowly bleaches the scintillator, reducing sensitivity.

Cleaning

WARNING!

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

Controller and Camera

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

Optical Surfaces

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.

Repairs

Save the original packing materials. Because the VersArray camera system contains no user-serviceable parts, repairs must be done by Princeton Instruments. Should your system need repair, contact Princeton Instruments customer support for instructions (telephone, e-mail, and address information are provided on page 150 of this manual).

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

System Component Descriptions

VersArray Camera



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

Fiberoptic Configuration: You can custom order a VersArray camera with a fiberoptic bonded to the CCD. These fiberoptic cameras are ideal for lenseless direct imaging of phosphor screens, MCPs, image intensifiers, and other Lambertian sources. Princeton Instruments uses a unique, patented process (US patent 5,134,680) to bond the fiber directly to the CCD for maximum resolution and throughput. Imaging fiber bundles are available in a range of demagnifications from 1:1 to 5:1. The input fiberoptic can be as large as 165 mm in diameter. Do not hesitate to contact your Princeton Instruments representative for any custom requirement or refer to our VersArray models on our website at www.princetoninstruments.com.

Internal Shutter: For TE- and LN-cooled cameras, the standard internal shutter has a quartz shutter window to protect the shutter mechanism from external dust and humidity. Since each window causes a small signal loss, an optional shutter assembly may be available without the window: added caution must then be used in the handling and storage of the camera. The standard shutter for a TE-cooled camera is the 35 mm shutter (the ST-133 must be equipped with the 70 V shutter option) and for the LN-cooled camera it is the 40 mm shutter.

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

Cooling: Dark current is significantly reduced in VersArray camera systems through deep cooling of the CCD arrays. You can choose from either thermoelectric or cryogenic options to best match your application requirements and environment:

- **Thermoelectric cooling:** Cooling by this method uses a four-stage Peltier cooler in combination with either air- or coolant-circulation (liquid assist or liquid only). To prevent condensation and contamination from occurring, cameras cooled this way can either be evacuated or nitrogen backfilled. Cameras

under vacuum reach lower temperatures; nitrogen-backfilled cameras are relatively maintenance free. The thermoelectric camera heads feature cost-effective performance, ease of use, and cooling from -40 to -60°C .

- **Liquid Nitrogen cooling:** Cooling by this method virtually eliminates dark current through the containment of liquid nitrogen in a Dewar reservoir. The use of thermal-radiation shielding and thermal-isolation mounts makes extremely long integration times possible, in excess of 25 hours for a large-capacity Dewar. VersArray controllers provide stabilized temperature control of LN heads from -70°C to -120°C (-70°C to -110°C for large arrays).

Connectors:

Controller: Power, control signals, and data are transmitted between the ST-133 and the VersArray camera via the 25-pin D connector located on the rear of the detector. The Detector-Controller cable is secured by a slide-lock mechanism. Controller power must be OFF before connecting to or disconnecting from this connector.

Shutter: LEMO connector for driving an internal shutter. Controller power must be OFF before connecting to or disconnecting from this connector.

Fan: (TE only) There may be a fan located inside the camera's back panel. Its purpose is:

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

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

Coolant Ports: Thermoelectrically-cooled cameras are available with liquid-assisted or liquid-only or liquid-cooled only cooling. Two coolant ports are provided on the sides of these cameras. These quick-disconnect ports require 1/4" thin-wall plastic tubing or 3/8" I.D. thick-wall PVC tubing, depending on the VersArray model. Instructions for setting up coolant flow are provided on page 48.

Dewar: LN-cooled cameras are available in both the standard side-on and the end-on configuration. The Dewar for the standard side-on holds 1.7 liters of liquid nitrogen (LN). The Dewar for the end-on camera holds 2.2 liters of liquid nitrogen (LN).

An "all-directional" Dewar is also available from Princeton Instruments. This Dewar can operate in *any* angular orientation but holds about half as much LN as the standard Dewar (~ 0.85 liters). This reduced capacity translates to roughly half the hold time, as well.

Note: There is no simple way to determine if you have been shipped an all-directional system simply by observing the detector. If you are uncertain, check the shipping paperwork to verify that your Dewar is an all-directional model.

ST-133 Controller



Electronics: The ST-133 controller is a compact, high performance CCD Detector Controller for operation with Princeton Instruments* detectors. Designed for high speed and high performance image acquisition, the ST-133 offers data transfer at speeds up to 1 megapixel per second, standard video output for focusing and alignment. A variety of A/D converters are available to meet different speed and resolution requirements.

In addition to containing the power supply, the controller contains the analog and digital electronics, scan control and exposure timing hardware, and controller I/O connectors, all mounted on user-accessible plug-in modules. This highly modularized design gives flexibility and allows for convenient servicing.

POWER Switch and Indicator: The power switch location and characteristics depend on the version of ST-133 Controller that was shipped with your system. In some versions, the power switch (located on the front panel as shown in Figure 2), has an integral indicator LED that lights whenever the ST-133 is powered. In other versions, the power switch is located on the back of the ST-133 and does not include an indicator LED.

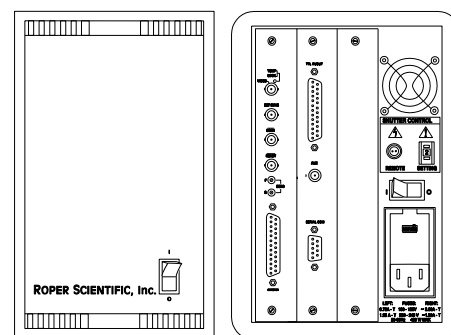


Figure 2. Power Switch Location (ST-133A and ST-133B)

Rear Panel Connectors: There are three controller board slots. Two are occupied by the plug-in cards that provide various controller functions. The third, covered with a blank panel, is reserved for future development. The left-most plug-in card is the Analog/Control module. Adjacent to it is the Interface Control module. Both modules align with top and bottom tracks and mate with a passive backplane via a 64-pin DIN connector. For proper operation, the location of the modules should not be changed. Each board is secured by two screws that also ground each module's front panel. The connectors and functions located on the rear panel are further described on the following page. Removing and inserting boards is described in Chapter 7, pages 104-105.

WARNING!

To minimize the risk of equipment damage, a module should *never* be removed or installed when the system is powered.

The **Analog/Control Module**, which should always be located in the left-most slot, provides the following functions.

- Pixel A/D conversion
- Timing and synchronization of readouts
- CCD scan control
- Temperature control
- Exposure control
- Video output control

* The ST-133 controller must be factory configured for operation with an LN detector. For this reason, a controller purchased for operation with an LN detector can only be used with an LN detector. Similarly, a controller purchased for operation with a TE-cooled detector can *not* be used with an LN detector.

The **Interface Control Module**, which should always be located in the center slot, provides the following functions.

- TTL In/Out Programmable Interface
- Communications Control (TAXI or USB 2.0 protocol)

WARNING! Always turn the power off at the Controller before connecting or disconnecting any cable that interconnects the camera and controller or serious damage to the CCD may result. This damage is **NOT** covered by the manufacturer’s warranty.

Rear Panel Features: The descriptions of the rear panel connectors are keyed to the accompanying figure. Depending on your system, either the TAXI or the USB 2.0 Interface Control Module will be installed in the second from the left slot (as you face the rear of the ST-133). In the Figure 3, the TAXI module is shown in that position.

#	Feature
1	Temperature Lock LED: Indicates that the temperature control loop has locked and that the temperature of the CCD array will be stable to within $\pm 0.05^{\circ}\text{C}$.
2	Video/Aux Output: If labeled Video, composite video output is provided at this connector. The amplitude is 1 V pk-pk and the source impedance is 75 Ω . If labeled Aux, this output is reserved for future use. Video output is not currently supported under USB 2.0.
3	External Sync Input: TTL input that has a 10 k Ω pullup resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) triggering can be selected.
4	SCAN Output: WinView/32 (ver. 2.4 and higher) software selectable NOT SCAN or SHUTTER signal. Default is SHUTTER.
5	READY Output: Initially HIGH. Changes state on completion of cleaning cycles before the first exposure.
6	Zero Adjustment: Bias potentiometers control the offset values of the Fast (F) and Slow (S) A/D converters. Preadjusted at factory. If potentiometers are not present, bias may be software-settable.

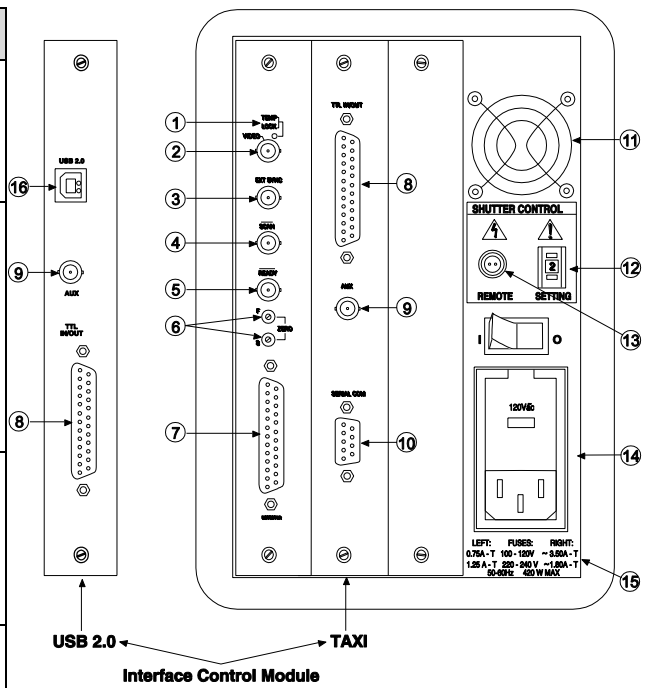


Figure 3. ST-133 Rear Panel Callouts

11	Fan: Cools the controller electronics. Runs continuously when the controller is turned on.
12	Shutter Setting Selector: Sets the shutter drive voltage. Dial is correctly set at the factory for the camera’s internal shutter if one is present.

#	Feature	#	Feature
7	Detector Connector: Transmits control information to the camera and receives data back from the camera via the Detector-Controller cable.	13	Remote Shutter Connector: Provides shutter-drive pulses for an external shutter. An ST-133 with the 70 V shutter option is required for a camera with the 40 mm shutter. A 70 V OPT label will be next to the Remote connector when this option is installed. WARNING: Dangerous live potentials are present at the Remote Shutter Power connector. To avoid shock hazard, the Controller power should be OFF when connecting or disconnecting a remote shutter.
8	TTL In/Out: User-programmable interface with eight input bits and eight output bits that can be written to or polled for additional control or functionality. Output is not currently supported under USB 2.0. See Chapter 6.	14	Power Module: Contains the powercord socket and two fuses. Depending on the ST-133 version, the power switch may be located directly above the power module.
9	AUX Output: Reserved for future use.	15	Fuse/Voltage Label: Displays the controller's power and fuse requirements. This label may appear below the power module.
10	Serial COM Connector: Provides two-way serial communication between the controller and the host computer.	16	USB 2.0 Connector: Provides two-way serial communication between the controller and the host computer. Uses USB 2.0 protocol.

Cables



Detector-Controller: The standard 10' (3 m) cable (6050-0321 for TE-cooled or 6050-0361 for LN-cooled camera) has DB-25 connectors with slide-latch locking hardware. This cable interconnects the Detector connector on the rear of the ST-133 with the Detector connector on the VersArray camera. The Detector-Controller cable is also available in 6', 15', 20', and 30' lengths.



Interface Cable: Depending on the system configuration, either a TAXI or a USB cable will be shipped.

TAXI: The standard 25' (7.6 m) cable (6050-0148-CE) has DB-9 Male connectors with screw-down locking hardware. The TAXI (Serial communication) cable interconnects the "Serial Com" connector on the rear of the ST-133 with the Princeton Instruments (RSPI) high speed PCI card installed in the host computer. In addition to the standard length, this cable is available in 10', 50', 100', and 165' lengths. Also available are fiber optic adapters with fiber optic cables in 100, 300, and 1000 meter lengths.

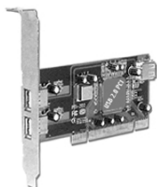


USB 2.0: The standard 16.4' (5 m) cable (6050-0494) has USB connectors that interconnect the "USB 2.0" connector on the rear of the ST-133 with a USB card installed in the host computer.

Interface Card



PCI Card: The Princeton Instruments (RSPI) high speed PCI card is required when the system interface uses the TAXI protocol rather than USB 2.0. The PCI card plugs-into the host computer's motherboard and provides the serial communication interface between the host computer and the ST-133. Through WinView/32, the card can be used in either **High Speed PCI** or **PCI(Timer)** mode. **High Speed PCI** allows data transfer to be interrupt-driven and can give higher performance in some situations. **PCI(Timer)** allows data transfer to be controlled by a polling timer.



USB 2.0 Card: The USB 2.0 card is required when the system interface uses the USB 2.0 protocol rather than TAXI protocol and the computer does not have native USB 2.0 support. The USB 2.0 card plugs-into the host computer's motherboard and provides the communication interface between the host computer and the ST-133. The USB 2.0 PCI card (70USB90011) by Orange Micro is recommended for desktop computers; the SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers. See www.orangemicro.com or www.siig.com, respectively, for more information.

Application Software

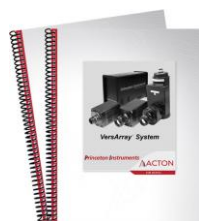


WinView/32: The Princeton Instruments software package provides comprehensive image acquisition, display, processing, and archiving functions so you can perform complete data acquisition and analysis without having to rely upon third-party software. WinView/32 provides reliable control over all Princeton Instruments cameras, regardless of array format and architecture, via an exclusive universal programming interface (PVCAM[®]). WinView/32 also features snap-ins and macro record functions to permit easy user customization of any function or sequence.

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

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

User Manuals



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

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

Chapter 3

Installation Overview

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

Action	Reference
1. If the system components have not already been unpacked, unpack them and inspect their carton(s) and the system components for in-transit damage.	Chapter 4 System Setup, page 26
2. Verify that all system components have been received.	Chapter 4 System Setup, page 26
3. If the components show no signs of damage, verify that the appropriate voltage settings have been selected for the Controller.	Chapter 4 System Setup, page 29
4. If the application software is not already installed in the host computer, install it.	Chapter 4 System Setup, page 30 & Software manual
5. If the appropriate interface card is not already installed in the host computer, install it.	Chapter 4 System Setup, page 30(TAXI-PCI) or page 32 (USB)
6. Depending on application, attach lens to camera, mount camera to spectrometer, or mount camera to a microscope	Chapter 4 System Setup, page 37, page 38, or page 42
7. With the Controller and computer power turned OFF, connect the interface cable to the Controller and the interface card in the host computer. Then tighten down the locking hardware.	Chapter 4 System Setup, page 34
8. With the Controller power turned OFF, connect the Detector-Controller cable to the appropriate connector on the rear of the Controller and the other end to the appropriate connector on the rear of the Camera . Adjust the slide latches so the cable connections are locked.	Chapter 4 System Setup, page 35 Chapter 7 Troubleshooting, page 106
9. With the Controller power turned OFF, connect the Controller power cable to the rear of the controller and to the power source.	Chapter 4 System Setup, page 35
10. If the system is cooled by coolant circulation, make the tubing connections between the coolant circulator and the camera. If the system is LN-cooled, DO NOT FILL DEWAR YET !!!	Chapter 4 System Setup, page 48
11. Turn the Controller ON .	
12. Turn on the computer and begin running the application software.	Software manual
13. Enter the hardware setup information or load the defaults from the controller.	Software manual

Action	Reference
14. Set the target array temperature.	Chapter 5 Operation, page 66
15. If the system is LN-cooled, fill the Dewar.	Chapter 4 System Setup, page 50
16. When the system reaches temperature lock, wait an additional 20 minutes and then begin acquiring data in focus mode.	Chapter 5 Operation, page 56 or page 60
17. Adjust the focus for the best image or spectral lines. If you are using WinSpec/32, you may want to use the Focus Helper function for this purpose.	Chapter 5 Operation, page 56 or page 60

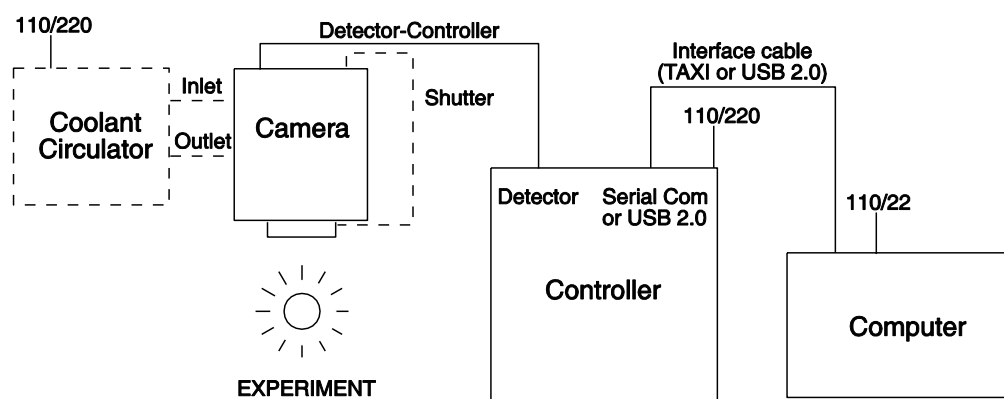


Figure 4. Imaging System Diagram: TE-cooled Camera

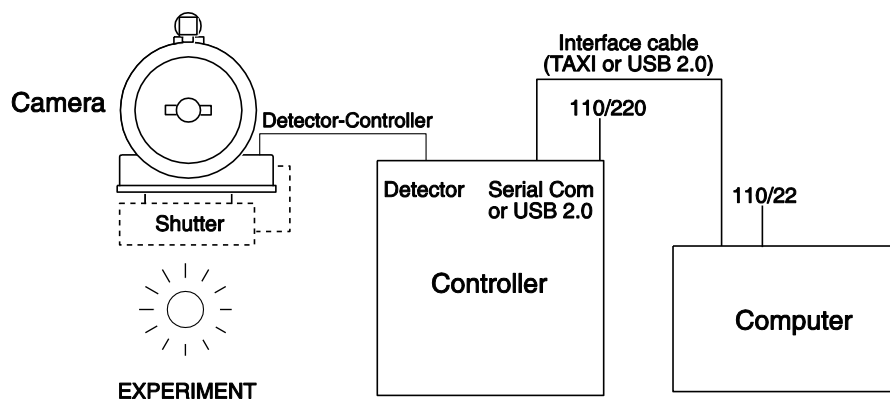


Figure 5. Imaging System Diagram: LN-cooled Camera

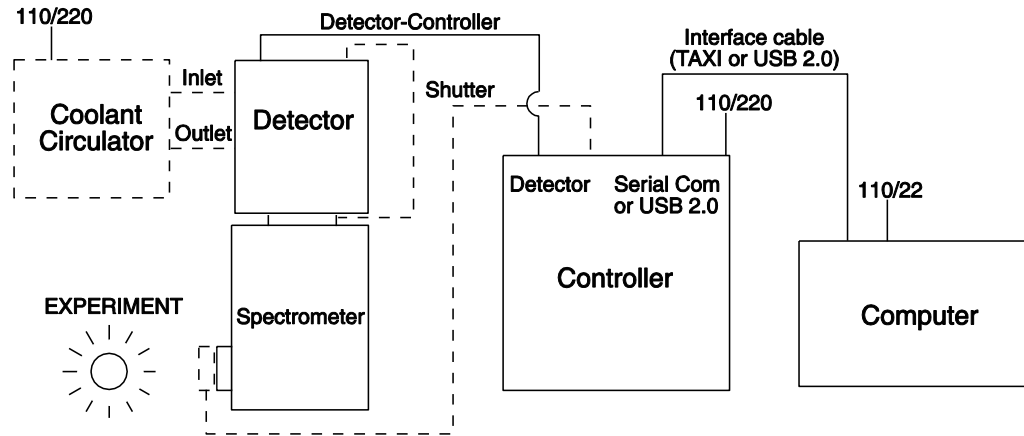


Figure 6. Spectroscopy System Diagram: TE-cooled Camera

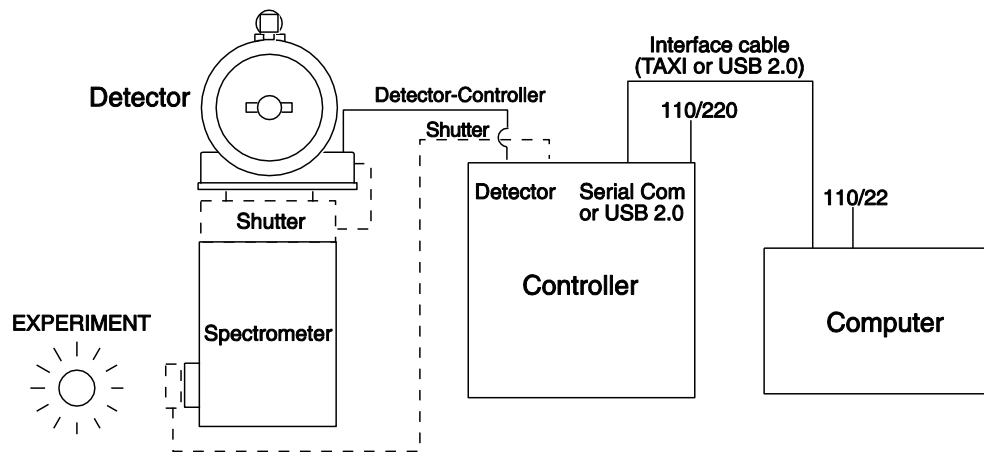


Figure 7. Spectroscopy System Diagram: LN-cooled Camera

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System Setup

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

Introduction

A VersArray camera system consists of four hardware components:

- Interface hardware
- Controller
- Camera head (air-assisted, liquid-assisted, or liquid-only thermoelectric; or LN)
- Cables

A VersArray system with a liquid-cooled camera head also requires a coolant circulator. All of the components and cables required for your configuration should be included with your shipment. Your VersArray system has been specially configured and calibrated to match the camera and readout rate options specified at the time of purchase. The CCD and coating you ordered has been installed in your camera head.

Keep all the original packing materials so you can safely ship the VersArray system to another location or return it for service if necessary. If you have any difficulty with any step of the instructions, call Princeton Instruments Customer Service. For contact information, refer to page 150.

Hardware installation may consist of:

- Installing an interface card.
- Attaching a lens to a C- or F-mount adapter.
- Connecting the camera to the controller.
- Selecting the appropriate power for an internal shutter.
- Connecting the camera to an external shutter, if one is required.
- Mounting the camera to a spectrometer or to a microscope.

VersArray System Configurations

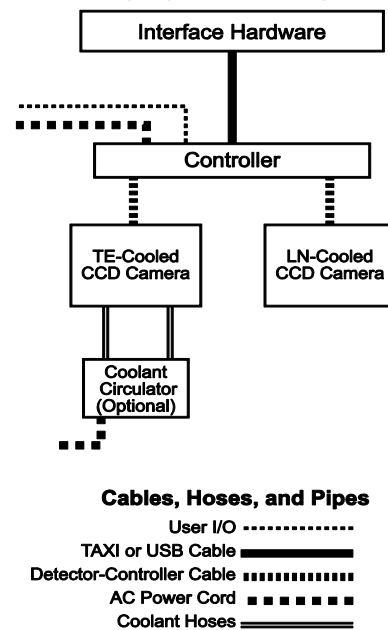


Figure 8. System Configurations

- Connecting the camera to a coolant supply.

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

Unpacking the System

During the unpacking, check the system components for possible signs of shipping damage. If there are any, notify Princeton Instruments and file a claim with the carrier. If damage is not apparent but camera 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 camera system to another location or return it to Princeton Instruments for repairs if necessary.

Checking the Equipment and Parts Inventory

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

- **Camera** (TE air-assisted, liquid-assisted, or liquid-cooled only; or LN-cooled).
- **Controller:** ST-133.
- **Detector-Controller cable:** DB25 to DB25 cable. Standard length is 10 ft (6050-0321 for TE-cooled cameras; 6050-0361 for LN-cooled). Also available in 6', 15', 20', and 30' lengths.
- **Host Computer:** Can be purchased from Princeton Instruments or provided by user.
- **Computer Interface Dependent Components:**
 - **Interface Card:**
 - **TAXI:** Princeton Instruments (RSPI) High Speed PCI Interface board or
 - **USB 2.0:** Native on motherboard or user-provided USB 2.0 Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop computers and the SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers).
 - **Controller-Computer Interface cable:**
 - **TAXI cable:** DB9 to DB9 cable (6050-0148-CE is standard) or
 - **USB cable:** Five (5) meter cable (6050-0494) is standard.
- **VersArray System User Manual**
- **WinView/32 CD-ROM** (optional)
- **System Dependent Cooling Components:**
 - Caron Chilled Coolant Circulator and Tubing/Fittings Kit

System Requirements

Environmental Requirements

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

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

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

Notes:

1. When using LN, periodic wiping of the Dewar vent ports may be required to prevent frost accumulation from interfering with venting. In a spectroscopy setup with an LN-cooled camera, high humidity conditions may require continuous flushing of the spectrometer's exit port with nitrogen.
2. For TE-cooled cameras, the shutter enclosure may have a quartz window that allows the shutter to be back-filled with dry nitrogen. This further reduces the possibility of condensation on the window of the camera. The shutter window, if present, can be seen whenever the lens is removed.
3. For TE-cooled cameras, the cooling performance may degrade if the room temperature is above $+23^{\circ}\text{C}$.

Ventilation

Detector: Allow at least one inch clearance for side and rear air vents. Where the detector is inside an enclosure, > 30 cfm air circulation and heat dissipation of 100W is required for TE air-cooled detectors.

ST-133: There is an internal fan located at the right side of the rear panel behind an exhaust opening. Its purpose is simply to cool the controller electronics. This fan runs continuously whenever the controller is powered. Air enters the unit through ventilation openings on the side panels, flows past the warm electronic components as it rises, and is drawn out the rear of the controller by the fan. It is important that there be an adequate airflow for proper functioning. As long as both the controller's intake ventilation openings and the fan exhaust opening aren't obstructed, the controller will remain quite cool.

Coolant

WARNING! COOLANT IS HARMFUL IF SWALLOWED.
KEEP OUT OF REACH OF CHILDREN.

VersArray cameras with liquid-assisted cooling or liquid-only cooling require circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation. The recommended flow rate and fluid pressure are: 2 liters/minute at 25 psig (maximum).

Power

Detector: The VersArray camera receives its power from the controller, which in turn plugs into a source of AC power.

ST-133: The ST-133 Controller can operate from any one of four different nominal line voltages: 100, 120, 220, or 240 V AC. Refer to the Fuse/Voltage label on the back of the ST-133 for fuse, voltage, and power consumption information.

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

Host Computer

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

Requirements for the host computer depend on the type of interface, TAXI or USB 2.0, that will be used for communication between the ST-133 and the host computer. Those requirements are a listed below according to protocol.

TAXI Protocol:

- AT-compatible computer with 200 MHz Pentium® II (or better).
- Windows® 95, Windows® 98SE, Windows® ME, Windows NT®, Windows® 2000, or Windows® XP operating system.
- Princeton Instruments (RSPI) high speed PCI serial card (or an unused PCI card slot). Computers purchased from Princeton Instruments are shipped with the PCI card installed if High speed PCI was ordered.
- Minimum of 32 Mbytes of RAM for CCDs up to 1.4 million pixels. Collecting multiple spectra at full frame or high speed may require 128 Mbytes or more of RAM.
- CD-ROM drive.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes and the remainder is required for data storage, depending on the number and size of spectra collected. Disk level compression programs are not recommended.
- Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- IEEE-488 GPIB port (required by DG535 Timing Generator, if present). May also be required by Spectrograph.
- Two-button Microsoft compatible serial mouse or Logitech® three-button serial/bus mouse.

USB 2.0 Protocol:

- AT-compatible computer with Pentium 3 or better processor and runs at 1 GHz or better.
- Windows 2000 (with Service Pack 4), Windows XP (with Service Pack 1) or later operating system.

- Native USB 2.0 support on the mother board or USB Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop; SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop)
- Minimum of 256 Mb of RAM.
- CD-ROM drive.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes and the remainder is required for data storage, depending on the number and size of spectra collected. Disk level compression programs are not recommended.
- Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- IEEE-488 GPIB port (required by DG535 Timing Generator, if present). May also be required by Spectrograph.
- Two-button Microsoft compatible serial mouse or Logitech three-button serial/bus mouse.

Verifying Voltage Settings

The Power Module on the rear of the Controller contains the voltage selector drum, fuses and the powercord connector. The appropriate voltage setting is set at the factory and can be seen on the back of the power module.

Each setting actually defines a range and the setting that is closest to the actual line voltage should have been selected. The fuse and power requirements are printed on the panel above the power module. The correct fuses for the country where the ST-133 is to be shipped are installed at the factory.

Note: Depending on the ST-133 version, voltage ranges and fuse ratings may be printed either above or below the power module (Figure 9).



Figure 9. Controller Power Module

To Check the Controller's Voltage Setting:

1. Look at the lower righthand corner on the rear of the Controller. The current voltage setting (100, 120, 220, or 240 VAC) is displayed on the Power Module.
2. If the setting is correct, continue with the installation. If it is not correct, follow the instructions on page 91 for changing the voltage setting and fuses.

Installing the Application Software

Installation is performed via the WinView/32 or WinSpec/32 installation process. If you are installing WinView or WinSpec for the first time and have a TAXI interface, you should run the installation before the Princeton Instruments (RSPI) PCI interface card is installed in the host computer. On the **Select Components** dialog box (see Figure 10), click on the **AUTO PCI** button to install the interface card drivers (PCI and the Princeton Instruments USB drivers) and the most commonly installed program files. Select the **Custom** button if you would like to choose among the available program files or do not want to install the PCI driver.

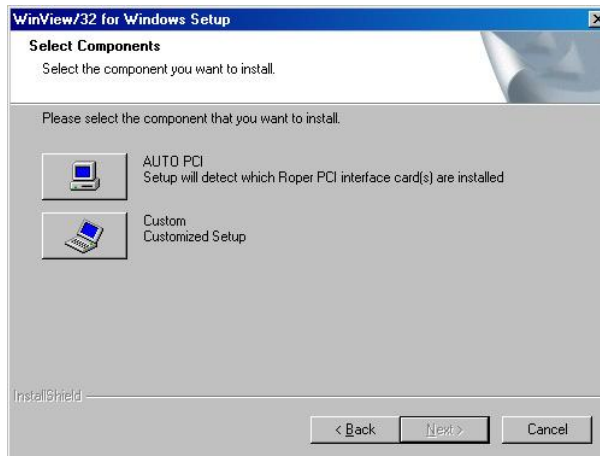


Figure 10. WinView Installation: Interface Card Driver Selection

Note: WinView/32 and WinSpec/32 (versions 2.6.0 and higher) do not support the ISA interface.

Setting up the Communication Interface

VersArray camera systems require either an installed Princeton Instruments (RSPI) PCI card or an installed USB2.0 interface card in the host computer. The type of interface card is dictated by the Interface Control Module installed in the ST-133 controller.

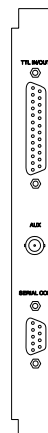
Setting up a PCI Interface

Administrator privileges are required under Windows NT®, Windows® 2000, and Windows® XP to install software and hardware.

A Princeton Instruments (RSPI) PCI card must be installed in the host computer if the communication between computer and controller uses the TAXI protocol (i.e., the **Interface Control Module** installed in the ST-133 has a 9-pin **SERIAL COM** connector as shown in the figure at right). With TAXI protocol, the standard cable provided with an ST-133 is 7.6 meters (25 feet). Cable lengths up to 50 meters (164 feet) are available and the digitization rate may be as high as 2 MHz.

A computer purchased from Princeton Instruments will be shipped with the PCI card already installed. Otherwise, a PCI card will be shipped with the system and you will have to install it in the host computer at your location.

Note: The PCI card can be installed and operated in any Macintosh having a PCI bus, allowing the ST-133 to be controlled from the Macintosh via IPLab™ software and the PI Extension.



Caution

If using WinX software, Select either **High Speed PCI** or **PCI(Timer)** as the Interface type. This selection is accessed on the **Hardware Setup|Interface** tab page. **High Speed PCI** allows data transfer to be interrupt-driven and gives the highest performance in some situations. **PCI(Timer)** allows data transfer to be controlled by a polling timer. This selection is recommended when there are multiple devices sharing the same interrupt.

To Install a PCI Serial Buffer Card in the Host Computer:

1. Review the documentation for your computer and PCI card before continuing with this installation.
2. To avoid risk of dangerous electrical shock and damage to the computer, verify that the computer power is OFF.
3. Remove the computer cover and verify that there is an available PCI slot.
4. Install the PCI card in the slot.
5. Make sure that the card is firmly seated and secure it.
6. Replace and secure the computer cover and turn on the computer only. If an error occurs at bootup, either the PCI card was not installed properly or there is an address or interrupt conflict. Refer to Chapter 9 "Troubleshooting", page 100 for instructions.

Note: The PCI card has no user-changeable jumpers or switches.

To Install the PCI Card Driver

The following information assumes that you have already installed the WinView/32 or WinSpec/32 software.

1. After you have secured the PCI card in the computer and replaced the cover, turn the computer on.
2. At bootup, Windows will try to install the new hardware. If it cannot locate the driver, you will be prompted to enter the directory path, either by keyboard entry or by using the browse function.

If you selected **AUTO PCI** during the application software installation, WinView/32 or WinSpec/32 automatically put the required INF file into the Windows/INF directory and put the PCI card driver file in the "Windows"/System32/ Drivers directory. Refer to Table 1 for the appropriate file names and locations.

Windows Version	PCI INF Filename Located in "Windows"/INF directory*	PCI Device Driver Name Located in "Windows"/System32/Drivers directory
Windows® 2000 and XP	rspi.inf (in WINNT/INF, for example)	rspipci.sys (in WINNT/System32/Drivers, for example)
Windows NT®	N/A	pi_pci.sys
Windows® 95, 98, and Windows® ME	pii.inf	pivxdpci.vxd

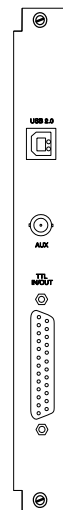
* The INF directory may be hidden.

Table 1. PCI Driver Files and Locations

Setting up a USB 2.0 Interface

Administrator privileges are required under Windows® 2000 and Windows® XP to install software and hardware.

Your system has been configured to use the USB communication protocol if the **Interface Control Module** installed in the ST-133 has a **USB 2.0** connector as shown in the figure at right). The advantages to the USB 2.0 interface are that it uses a much higher data transfer rate than many common serial data formats (such as the TAXI protocol) and it simplifies the connection to external devices. USB supports "plug and play" -- you do not need to be heavily involved in the setup process.



USB 2.0 Limitations

- Maximum cable length is 5 meters (16.4 feet)
- 1 MHz is currently the upper digitization rate limit for the ST-133 Controller. Large data sets and/or long acquisition times may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (Easy DLLS).
- Some WinView and WinSpec 2.5.X features are not fully supported with USB 2.0. Refer to Appendix E, page 139, for more information.

Note: If you are installing the USB 2.0 interface on a laptop, you will need to perform all of the operations described in this section. In addition, if you are using the recommended USB Interface Card (SIIG, Inc. USB 2.0 PC Card, Model US2246), you must replace the OrangeUSB USB 2.0 Host Controller driver installed for that card with the appropriate Microsoft driver. Instructions for making the replacement are included in "*To Update the OrangeUSB USB 2.0 Driver*".

To Update the OrangeUSB USB 2.0 Driver:

This procedure is highly recommended when a laptop computer will be used to communicate with the ST-133. As stated before, we recommend the SIIG, Inc. USB 2.0 PC Card, Model US2246 if USB 2.0 is not native to the laptop's motherboard. To reduce the instances of data overruns and serial violations, the OrangeUSB USB 2.0 Host Controller installed for the SIIG card, should be replaced by the appropriate Microsoft driver (Windows 2000 or Windows XP, depending on the laptop's operating system.)

Note: This procedure may also be performed for desktop computers that use the Orange Micro 70USB90011 USB2.0 PCI.

1. Download and install Microsoft Service Pack 4 (for Windows 2000) or Service Pack 1 (for Windows XP) if the service pack has not been installed.
2. From the Windows **Start** menu, select **Settings|Control Panel**.
3. Select **System** and then **System Properties**.
4. Select the **Hardware** tab and click on **Device Manager** button.
5. Expand **Universal Serial Bus Controllers**.
6. Right-mouse click on **OrangeUSB USB 2.0 Host Controller** and select **Properties**.

7. On the **Driver** tab, click on the **Update Driver...** button. You may have to wait a minute or so before you will be allowed to click on the button.
8. When the **Upgrade Device Driver wizard** appears, click on **Next**. Select the **Search for a suitable driver ...** radio button.
9. On the next screen select the **Specify a location** checkbox.
10. Browse and select the location. Click on **OK**.
11. In the **Driver Files Search Results** window, check the **Install one of the other drivers** check box.
12. Select the **NEC PCI to USB Enhanced Host Controller B1** driver. Click on **Next** and the installation will take place. When the **Completing the Upgrade Device Driver wizard** window appears, click on **Finish**. You will then be given the choice of restarting the computer now or later. According to the window text, the hardware associated with the driver will not work until you restart the computer.

To Install the Princeton Instruments USB2 Interface:

The following information assumes that:

- You have verified that the host computer meets the required specifications for USB 2.0 communication with the VersArray system (see page 28).
- A USB 2.0 board and its driver are installed in the host computer.
- The ST-133 has an installed USB 2.0 Interface Control module.
- You have already installed the WinX software (versions 2.5.15 and higher). Versions 2.5.15 and higher automatically install the driver and INF files required to support the USB 2.0 Interface Control module.

1. Before installing the Princeton Instruments USB2 Interface, we recommend that you defragment the host computer's hard disk. This operation reduces the time the computer spends locating files. Typically, the "defrag" utility "Disk Defragmenter" can be accessed from the Windows® Start menu and can usually accessed from the Programs/Accessories/System Tools subdirectory.
2. After defragmenting the hard disk, turn off the computer and make the USB cable connections between the host computer and the ST-133. Then, turn the ST-133 on before turning on the host computer.
3. At bootup, Windows will detect the Princeton Instruments USB2 Interface hardware (i.e., the USB 2.0 Interface Control module). You may be prompted to enter the directory path(s) for the `apausbprop.dll` and/or the `apausb.sys` file(s), either by keyboard entry or by using the browse function.

If you selected **AUTO PCI** during the application software installation, WinX automatically put the required INF, DLL, and USB driver file in the "Windows" directories shown below. Refer to the Table 2 for the file locations.

Windows Version	USB INF Filename Located in "Windows"/INF directory*	USB Properties DLL Located in "Windows"/System32 directory	USB Device Driver Name Located in "Windows"/System32/Drivers directory
Windows® 2000 and XP	rsusb2k.inf (in WINNT/INF, for example)	apausbprop.dll (in WINNT/System32, for example)	apausb.sys (in WINNT/System32/Drivers, for example)

* The INF directory may be hidden.

Table 2. USB Driver Files and Locations

Connecting the Interface (Controller-Computer) Cable

TAXI® Cable (6050-0148-CE)

Turn the Controller power OFF (OFF = 0, ON = |) and the Computer power OFF before connecting or disconnecting the Controller-Computer (TAXI) cable.

To Connect the TAXI Cable:

1. Verify that the Controller power is OFF.
2. Verify that the Computer power is OFF.
3. Connect one end of the TAXI cable to the 9-pin port on the Interface card in the host computer.
4. Tighten down the screws to lock the connector in place.
5. Connect the other end of the cable to the "Serial Com" port on the rear of the Controller.
6. Tighten down the screws to lock the connector in place.

USB 2.0 Cable (6050-0494)

Turn the Controller power OFF (OFF = 0, ON = |) and the Computer power OFF before connecting or disconnecting the Controller-Computer (TAXI) cable.

To Connect the USB 2.0 Cable:

1. Verify that the Controller power is OFF.
2. Verify that the Computer power is OFF.
3. Connect one end of the USB cable to the USB port on the host computer.
4. Connect the other end of the cable to the USB 2.0 port on the rear of the Controller.

Connecting the Detector-Controller Cable

Turn the Controller power OFF (OFF = 0, ON = 1) before connecting or disconnecting the detector-Controller cable.

To Connect the detector-Controller Cable:

1. Verify that the Controller power is OFF.
2. Connect male end of the Detector-Controller cable (6050-0321 for TE-cooled cameras; 6050-0361 for LN-cooled) to the “Detector” port on the back of the Controller. Refer to "*Securing the Detector-Controller Cable Slide Latch*", page 106.
3. Move the slide latch down to lock the connector in place.
4. Connect the female end of the cable to the Camera.
5. Lock the connector in place. Depending on the detector and the cable used, this operation may require tightening down locking screws or securing a slide-latch.

Entering the Default Camera System Parameters into WinX (WinView/32, WinSpec/32, or WinXTest/32)

Software changes implemented in WinX version 2.15.9.6 affected the way in which default parameters were entered for camera systems. Therefore, two sets of instructions are included. Follow the instructions appropriate to the software version that you installed. Note that these instructions assume that you have performed the computer interface installation.

WinX Versions 2.5.19.6 and later

1. Make sure the ST-133 is connected to the host computer and that it is turned on.
2. Run the WinX application. The **Camera Detection wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard...** button on the **Controller/CCD** tab page to start the wizard.
3. On the **Welcome** dialog (Figure 11), leave the checkbox unselected and click on **Next**.

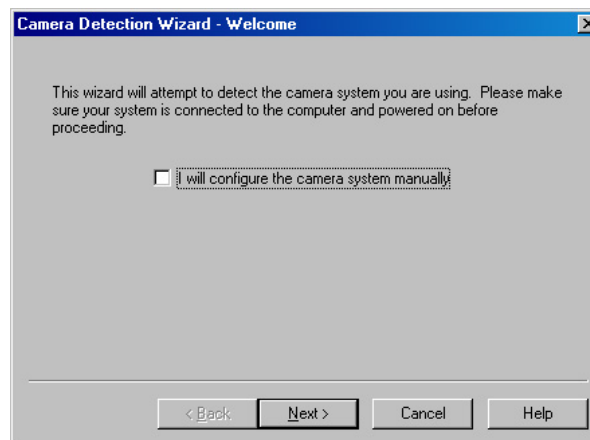


Figure 11. Camera Detection Wizard - Welcome dialog box

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

WinX Versions before 2.5.19.6: Run RSConfig.exe

- Make sure the ST-133 is connected to the host computer and that it is turned on.
- Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed WinView, WinSpec, or WinXTest.
- When the RSConfig dialog box (Figure 12) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

Note: If the first camera in the list is not the "Princeton Style (USB2)", you will need to edit the PVCAM.INI file created by RSConfig. See the instructions in "*Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog*", page 96.

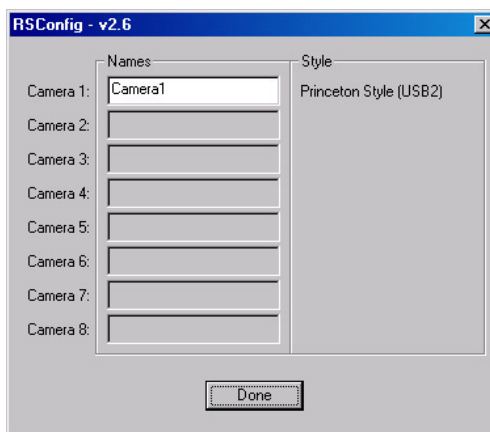


Figure 12. RSConfig dialog box

- Open the WinX application and, from **Setup|Hardware...**, run the Hardware Setup wizard.
- When the PVCAM dialog box (Figure 13) is displayed, click in the **Yes** radio button, click on **Next** and continue through the wizard. After the wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to set up experiments and acquire data.



Figure 13. Hardware Setup wizard: PVCAM dialog box

- Run the software in focus mode to verify communication between the ST-133 and the host computer.

Attaching Lenses to C- and F-Mount Adapters

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

Attaching to a C-Mount Adapter

Standard TE-cooled cameras and some TE-cooled cameras with the "microscope nose" can be ordered with an integral C-mount adapter. C-mount lenses simply screw into the front of these cameras. Tighten the lens by hand only.

Connecting to a microscope is discussed in "*Mounting a TE-Cooled VersArray Camera to a Microscope*" on page 42. If you cannot use the adapter you received, contact the factory for customer support or replacement. *See page 150 for Information on accessing the Princeton Instruments Customer Support Dept.*

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

Attaching to an F-Mount Adapter

Cameras for use in imaging systems (cameras) are shipped with the lens mount already attached. Standard Princeton Instruments lens mounts use the Nikon bayonet format, as shown in Figure 14 and Figure 15. This can be converted to most other formats by using commercially available adapters. If your optical system cannot be converted to this format, contact the factory. *Other mounts may be available. Consult the factory for specific information relating to your needs. See page 150 for Information on accessing the Princeton Instruments Customer Support Dept.*

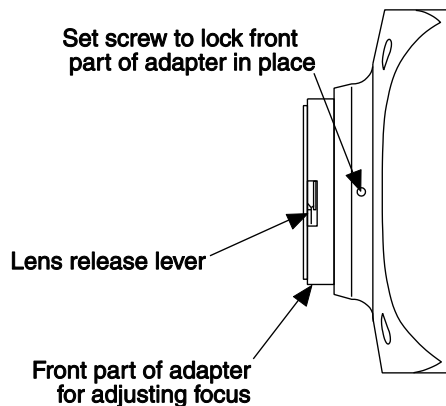


Figure 14. F-Mount Adapter 1 for TE-Cooled Cameras

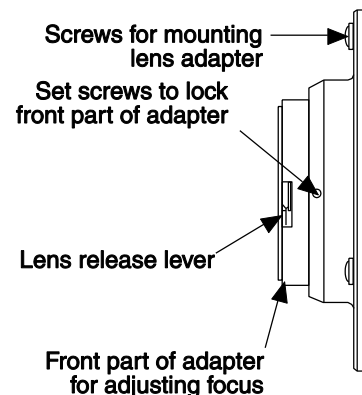


Figure 15. F-Mount Adapter 2 for TE- and LN-Cooled Cameras

To Mount the Lens on the Camera:

1. Locate the large indicator dot on the side of the lens.
2. Note the corresponding dot on the front side of the adapter.

3. Line up the dots and slide the lens into the adapter.
4. Turn the lens counterclockwise until a click is heard. The lens is now locked in place.
5. In addition to the focusing ring of the lens, there is provision for focusing the adapter itself. That adjustment is secured by setscrews on the side of the adapter's adjustment ring. Directions for focusing the lens *and* the adapter are provided on page 127.

To Remove the Lens:

1. Locate the lens release lever at the front of the lens mount.
2. Press the lever toward the camera housing and simultaneously rotate the lens clockwise.
3. Then pull the lens straight out.

Although microscopes more commonly are used with a C-mount adapter, operation with a camera having an F-mount adapter may also be possible. See "*Mounting a TE-Cooled VersArray Camera to a Microscope*" on page 42, *Microscopy Applications* and the adapter literature for further directions.

WARNING!

The standard LN-cooled side-looking camera or an end-looking LN-cooled camera must never be tilted more than 30° from vertical unless the "all-directional" Dewar option has been purchased. If mounting the camera to your system means that you will tilt the Dewar more than 30°, you may have the wrong type of Dewar. Contact the factory.

Mounting to a Spectrometer

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



Because of the many possible VersArray camera and spectrometer combinations, all of the adapter mounting instructions are located in Appendix D. Refer to the table at the beginning of that appendix to find the instruction set appropriate to your system.

WARNING!

A Dewar must never be tilted more than 30° from vertical, unless the "all-directional" Dewar option has been purchased. For this reason, a side-looking camera and an end-looking camera are available for mounting to vertical and horizontal image planes, respectively. 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.

Focal Plane Distance

The distance to the focal plane from the front of the mechanical assembly depends on the specific configuration. Refer to "*Focal Distance*" on page 109 for more information.

In addition, the focal distance for an end-on Dewar detector is affected by the shrinkage that occurs as the detector cools to its operating temperature. The change is approximately $+0.047$ " (1.194 mm) as the CCD shifts up toward the bottom of the Dewar. Because of this movement, an image area or a focus set at room temperature will change as a detector cools.

In the past, Princeton Instruments LN-cooled detectors were designed so the focal distance for end-on Dewars was set at room temperature. When the detectors cooled down to operating temperature, the offset would become apparent and the user might be required to shift the region of interest, move a slit, or refocus.

The new integral nose LN-cooled detectors (as of 2004) have been designed so the focal distance for end-on Dewars is offset at room temperature. Now, when a detector cools to operating temperature the focal distance is as noted on the end-on Dewar outline drawing.

Optical Center of the Array

An LN-cooled detector shrinks when the Dewar is filled with LN and the detector cools down to operating temperature. For side-on Dewars, the optical center of the CCD shifts (towards the fill port) by approximately $.035$ " (.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.

In the past, Princeton Instruments LN-cooled detectors were designed so the optical center of a CCD (side-on Dewars) was set at room temperature. When the detectors cooled down to operating temperature, the offset would become apparent and the user might be required to shift the region of interest, move a slit, or refocus.

The new integral nose LN-cooled detectors (as of 2004) have been designed so the optical center of a CCD (side-on Dewars) is offset at room temperature. Now, when a detector cools to operating temperature, the optical center of the CCD is at the center of the nose (side-on Dewars).

Array Orientation

For square format CCDs (for example, 512×512 , 1340×1300 , or 2048×2048) you may orient the CCD to achieve binning along either direction of the CCD.

- Binning along columns (parallel mode) provides maximum scan rate and lowest noise.
- Binning along the rows (perpendicular mode) minimizes crosstalk and is therefore better for multi-spectral applications. The drawback to this method is that scanning is slower and noise may increase somewhat.

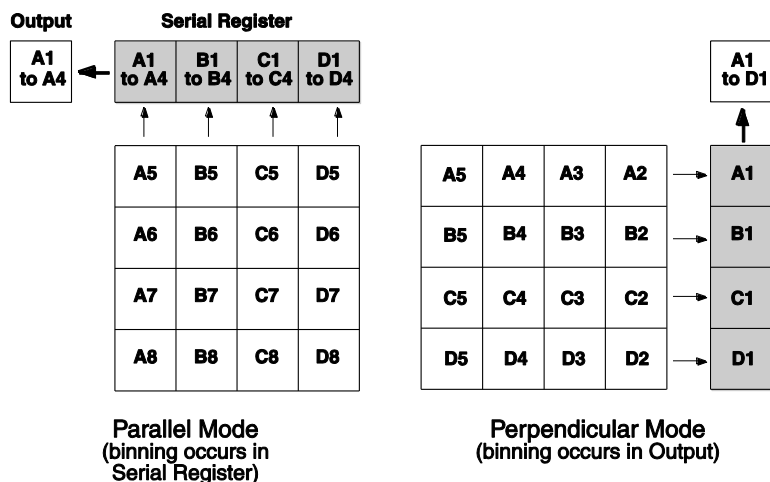


Figure 16. Binning and Array Orientation

Note: Users of TE-cooled cameras can easily switch between these orientations by rotating the camera 90° and changing the binning parameters in the application software.

Camera-Spectrometer Adapters

Princeton Instruments has a variety of adapters for mating VersArray cameras to spectrometers. In some cases, the appropriate adapter is mounted to the camera before the detector is shipped from the factory. In other cases, an adapter kit, containing mounting hardware and adapter(s), is shipped with the detector. Refer to Appendix D for mounting instructions.

Entrance Slit Shutter

This shutter can either be mounted on the entrance slit of the spectrometer or used as a stand-alone shutter. Shutters for stand-alone operation have two tapped holes for mounting to a stand: one metric, the other English.

Entrance slit shutter mounts come in two types. The first type is for use with CP-200 and HR-250 Spectrometers, and is shown in Figure 17.

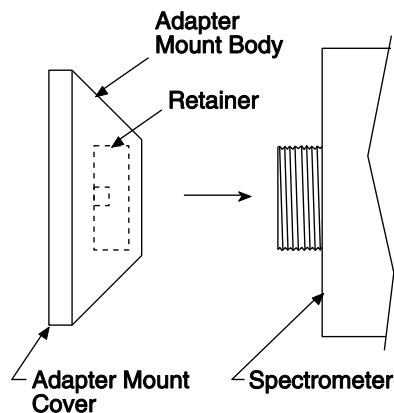


Figure 17. Type 1 Entrance Slit Shutter Mount

Type 1 Shutter Mount Directions

1. Remove the Adapter Mount Cover by removing the four Phillips head screws.
2. Place the Adapter Mount Body over the entrance slit.
3. Mount it by threading the Retainer to the spectrograph.
4. Replace the shutter and the Adapter Mount Cover.

Type 2 Shutter Mount Directions

The second shutter mount type, used with all Acton Research spectrographs, requires no disassembly. Mount it to the spectrograph as shown in Figure 18.

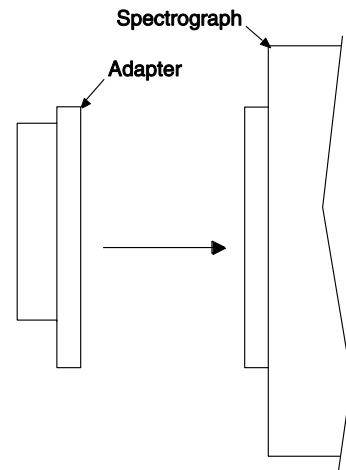


Figure 18. Type 2 Entrance Slit Mount

Shutter Cable Connection

WARNING!



Dangerous live potentials are present at the Remote **Shutter** power connector. To avoid shock hazard, the Controller power should be OFF when connecting or disconnecting a remote shutter.

1. Verify that the ST-133 controller is turned OFF (or not connected)
2. Connect the shutter cable to the side of the camera.
3. Then connect the other end to either the Shutter Power connector on the camera or to the Shutter Power connector on the ST-133 controller. In the case of TE cameras, the shutter cable should be connected to the Shutter Power connector on the rear panel of the camera or to the Shutter Power connector on the ST-133 Controller. In many systems, cable length considerations will make it more convenient to connect to the Shutter Power connector on the camera.

Note: Longer cables are available from the factory.

Overexposure Protection

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

Notes:

1. If the CCD is cooled to low temperatures (below -50°C), exposure to ambient light will over-saturate it. This may increase dark charge significantly. If the camera remains saturated after all light sources are removed, you may have to bring the camera back to room temperature to restore dark charge to its original level.
2. Saturation is not harmful to a non-intensified camera.

Mounting a TE-Cooled VersArray Camera to a Microscope

Introduction

This section discusses the setup and optimization of your digital imaging system as applied to microscopy.

Since scientific grade cooled CCD imaging systems are usually employed for low light level microscopy, the major goal is to maximize the light throughput to the camera. In order to do this, the highest Numerical Aperture (NA) objectives of the desired magnification should be used. In addition, you should carefully consider the transmission efficiency of the objective for the excitation and emission wavelengths of the fluorescent probe employed. Another way to maximize the transmission of light is to choose the camera port that uses the fewest optical surfaces in the pathway, since each surface results in a small loss in light throughput. Often the trinocular mount on the upright microscope and the bottom port on the inverted microscope provide the highest light throughput. Check with the manufacturer of your microscope to determine the optimal path for your experiment type.

A rule of thumb employed in live cell fluorescence microscopy is "if you can see the fluorescence by eye, then the illumination intensity is too high". While this may not be universally applicable, it is a reasonable goal to aim for. In doing this, the properties of the CCD in your camera should also be considered in the design of your experiments. For instance, if you have flexibility in choosing fluorescent probes, then you should take advantage of the higher Quantum Efficiency (QE) of the CCD at longer wavelengths (QE curves can be found on the Princeton Instruments camera data sheets). Another feature to exploit is the high resolution offered by cameras with exceptionally small pixel sizes (data available on the Princeton Instruments camera data sheets). Given that sufficient detail is preserved, you can use 2x2 binning (or higher) to increase the light collected at each "super-pixel" by a factor of 4 (or higher). This will allow the user to reduce exposure times, increasing temporal resolution and reducing photodamage to the living specimen.

Another method to minimize photodamage to biological preparations is to synchronize a shutter on the excitation pathway to the exposure period of the camera. This will limit exposure of the sample to the potentially damaging effects of the excitation light.

Mounting the Camera on the Microscope

The camera is connected to the microscope via a standard type mount coupled to a microscope specific adapter piece. There are two basic camera-mounting designs, the F-mount (standard) and the C-mount (optional). The F-mount uses a tongue and groove type mechanism to connect to the camera while the C-mount employs a standard size thread to make the connection.

F-Mount

For a camera with the F-mount type design, you need two elements to mount the camera on your microscope:

- **A Diagnostic Instruments Relay Lens.** This lens is usually a 1x relay lens that performs no magnification. Alternatively, you may use a 0.6x relay lens to partially demagnify the image and to increase the field of view. There is also a 2x relay lens available for additional magnification.
- **A Microscope-specific Diagnostic Instruments Bottom Clamp.** Table 3 shows which bottom clamps are routinely used with each of the microscope types. They are illustrated in Figure 20. If you feel that you have received the wrong type of clamp, or if you need a clamp for a microscope other than those listed, please contact the factory.

To Mount the Camera:

1. First, pick up the camera and look for the black dot on the front surface.
2. Match this dot with the red dot on the side of the relay lens.
3. Then engage the two surfaces and rotate them until the F-mount is secured as evidenced by a soft clicking sound.
4. Next place the long tube of the relay lens into the bottom clamp for your microscope, securing it to the relay lens with the three set screws at the top of the clamp as shown in Figure 19.
5. This whole assembly can now be placed on the microscope, using the appropriate setscrews on the microscope to secure the bottom clamp to the output port of the microscope.
6. The F-mount is appropriate for any trinocular output port or any side port.

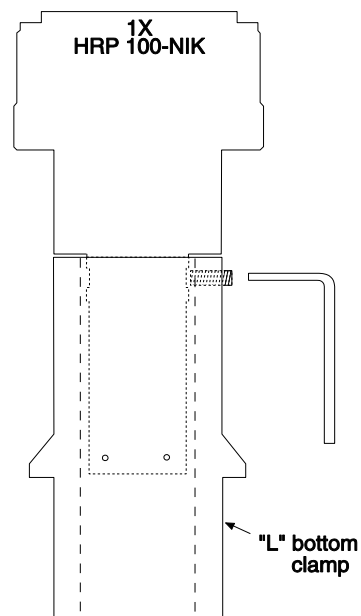


Figure 19. Bottom Clamp Secured to Relay Lens

- When mounting the camera perpendicular to the microscope on the side port, it is ADVISED that you provide some additional support for your camera to reduce the possibility of vibrations or excessive stress on the F-mount nose.
- Princeton Instruments DOES NOT advise using an F-mount to secure the camera to a bottom port of an inverted microscope due to possible failure of the locking mechanism of the F-mount. *Contact the factory for information about a special adapter for operating in this configuration.*

C-Mount

For a camera equipped with a C-mount thread, use the standard C-mount adapter that is supplied by the microscope manufacturer to attach the camera to the microscope.

1. Screw the adapter into the camera.
2. Secure the assembly to the microscope using the standard setscrews on the microscope. The camera can be mounted on the trinocular output port, the side port or the bottom port of the inverted microscope.
3. If you are mounting one of the LARGER cameras in the following orientations, it is ADVISED that you provide additional support for the camera:
 - **Perpendicular to the microscope, on the side port.** Additional support is advised to reduce vibrations or excessive stress on the C-mount nose.
 - **At the bottom port of the inverted microscope.** The C-mount is designed to support the full weight of the camera. However, additional support is advisable since the camera is in a position where it could be deflected by the operator's knee or foot. This kind of lateral force could damage the alignment of the nose and result in sub-optimal imaging conditions.
4. If additional optical elements are required at an output port for image collection, please check with your microscope manual to determine if the chosen output port requires a relay lens.
5. Verify that all optical surfaces are free from dust and fingerprints, since these will appear as blurry regions or spots and hence degrade the image quality.

Microscope Type	Diagnostic Instruments Bottom Clamp Type
Leica DMR	L-clamp
Leitz All types	NLW-clamp
Nikon Optiphot, Diaphot, Eclipse	O-clamp
Olympus BH-2, B-MAX, IMT-2	V-clamp
Zeiss Axioscope, Axioplan, Axioplan 2, Axiophot	Z-clamp
Zeiss Axiovert	ZN-clamp

Table 3. Bottom Clamps for Different Microscopes

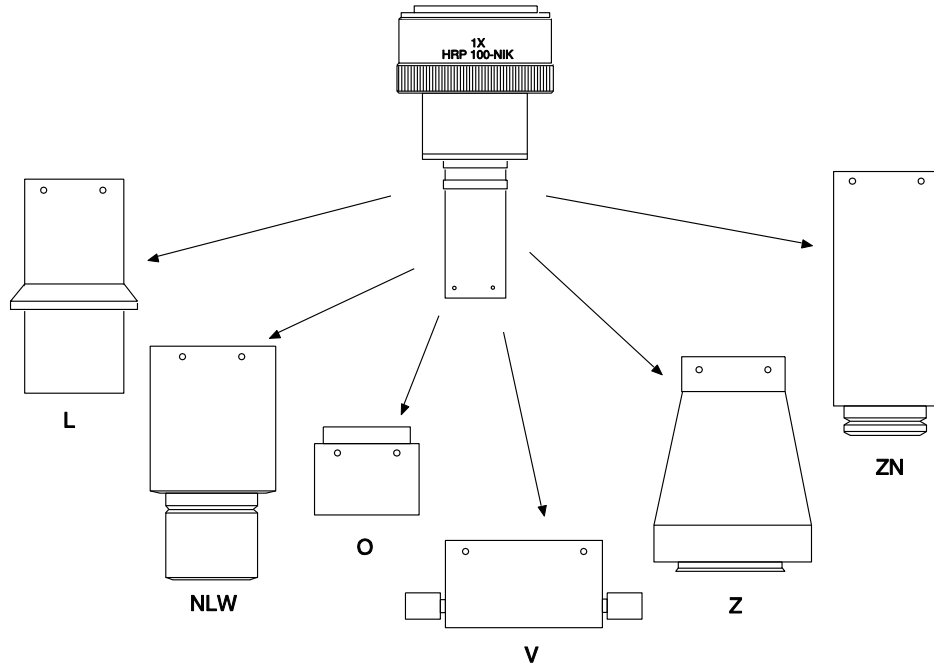


Figure 20. Diagnostic Instruments Bottom Clamps for Different Microscopes

Adjusting the Parfocality of the Camera

After the camera has been mounted, verify that you get a clear, focused, transmitted light image through the eyepiece. Then, divert the light to the camera and lower the illuminating light intensity.

To adjust the parfocality on an F-mount system:

- Begin collecting images with a short exposure time.
- Focus the light on the camera by rotating the ring on the Diagnostic Instruments relay lens without touching the main focusing knobs on the microscope.

To adjust the parfocality on a C-mount system:

On a C-mount system, the camera should be very close to parfocal, although some C-mounts will be adjustable using setscrews on the microscope to secure the adapter slightly higher or lower in position.

To focus a Camera with an F-mount Lens Adapter:

Focusing is normally done by means a focus adjustment on the relay-lens adapter.

Note: The camera lens mount itself also has a focus adjustment. Although it is unlikely that you would ever need to use this adjustment in operation with a microscope (it is preferable that you use the relay-lens focus adjustment), it could be used if necessary. The procedure for using the adjustment is provided in Appendix C, page 127.

Caution

Microscope optics have very high transmission efficiencies in the infrared region of the spectrum. Since typical microscope light sources are very good emitters in the infrared, some microscopes are equipped with IR blockers or heat filters to prevent heating of optical elements or the sample. For microscopes that do not have the better IR blockers, the throughput of infrared light to the CCD can be fairly high. In addition, while the eye is unable to see the light, CCD cameras are particularly efficient in detecting infrared wavelengths. As a result, the contaminating infrared light will cause a degradation of the image quality due to a high background signal that will be invisible to the eye. Therefore, it is recommended that you add an IR blocker prior to the camera if you encounter this problem with the microscope.

WARNING!

Before You Start, if your system includes a microscope Xenon or Hg arc lamp, it is **CRITICAL** to turn off all electronics adjacent to the arc lamp, especially your digital camera system and your computer hardware (monitors included) before turning on the lamp power.

Powering up a microscope Xenon or Hg arc lamp causes a large EMF spike to be produced that can cause damage to electronics that are running in the vicinity of the lamp. We advise that you place a clear warning sign on the power button of your arc lamp reminding all workers to follow this procedure. While Princeton Instruments has taken great care to isolate its sensitive circuitry from EMF sources, we cannot guarantee that this protection will be sufficient for all EMF bursts. *Therefore, in order to fully guarantee the performance of your system, you must follow this startup procedure.*

Attaching/Connecting Shutters

Internal Shutters

WARNING!

Disconnecting or connecting the shutter cable to the camera while the controller is on can destroy the shutter or the shutter driver in the controller!

A camera will have an internal shutter if ordered by the user.

- **TE-cooled Cameras:** C-mount cameras use a 25 mm internal shutter that is housed in the main body. F-mount cameras use a 35 mm shutter that is housed in an additional front section of the camera. Cameras with the 35 mm internal shutter must be controlled by an ST-133 Controller with the 70 Volt Option.
- **LN-cooled Cameras:** The 40 mm internal shutter is housed in the nose section of the camera. To accommodate the shutter, a deeper nose housing is used, with a resulting increase in the focal plane distance. The 70 Volt Option is not required by 40 mm shutters.

The only case in which an internal shutter will not be supplied is when an TE-cooled camera is configured for spectroscopic applications.

Note: Electromechanical shutters typically have a lifetime of about a million cycles. Avoid running the shutter unnecessarily. Also avoid using shorter exposure times and higher repetition rates than are required.

Shutter Cable

The **Shutter to Controller** cable connects an external shutter to the **Remote** Lemo connector on the rear of the controller. If the camera is equipped with an internal shutter, then the **Remote** connector should not be used to drive an external (second) shutter. Such a configuration will result in under-powering both shutters and may cause damage to the system. If your application requires both an internal and an external shutter, refer to the controller manual for the setup information.

WARNINGS



1. Dangerous live potentials are present at the **Remote** connector. To avoid shock hazard, always turn the controller power **OFF** before connecting or disconnecting an external shutter cable.
2. Disconnecting or connecting the shutter cable to the controller while the controller power is **ON** can destroy the shutter or the shutter driver in the controller.

35 mm Shutter

As shown in Figure 21, TE cameras having an F-mount nose use a 35 mm opening shutter. This shutter does not completely clear a large array (for example, a 1340×1300 array with ~38 mm diagonal) and the array is not fully illuminated.

This does not mean that the shutter is too small. The F-mount lens actually limits the field size ahead of the 35 mm shutter. *The difficulty is that the F-mount standard itself does not provide sufficient coverage to completely illuminate the large array.*

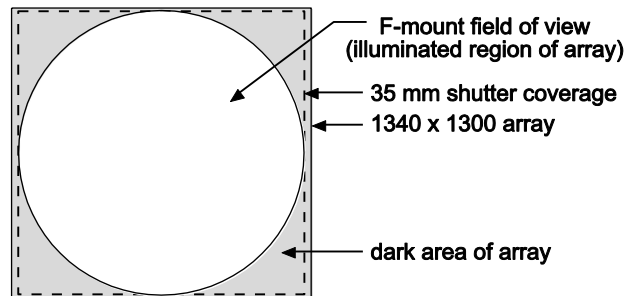


Figure 21. 35 mm Shutter Coverage on 1340×1300 Array for F-mount Design

Note that a camera having the 35 mm shutter can only be used with an ST-133 equipped with the 70 V shutter option. An ST-133 that has the 70 V shutter option can be identified by the **70 V OPT** label on its rear panel as shown in Figure 22.

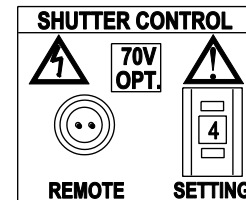


Figure 22. 70 V Shutter Option Label

Shutter Setting Selection

The Shutter Setting dial is correctly set at the factory for the camera's internal shutter if one is present.

1. Verify that the Controller power is OFF.
2. Refer to Table 4 when looking at the rear of the Controller. Verify that the correct shutter setting has been selected for the shutter you are using.
3. If the setting is not correct, press the "-" or the "+" button until the correct setting is displayed in the window.

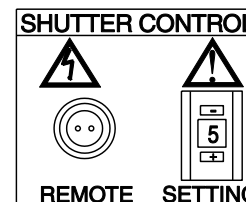


Figure 23. Shutter Setting for Large Internal Shutter (40 mm)

Shutter Setting*	Shutter Type
1	25 mm Princeton Instruments supplied External shutter (typically an Entrance slit shutter)
2	25 mm Princeton Instruments Internal shutter
4	35 mm Princeton Instruments Internal shutter (requires 70 V Shutter option)
5	40 mm Princeton Instruments Internal shutter (supplied with LN camera having a 1340 × 1300 or larger CCD)
* Shutter settings 0, 3, and 6-9 are unused and are reserved for future use.	

Table 4. ST-133 Shutter Setting Selection

WARNING!

An incorrect setting may cause the shutter to malfunction or be damaged. An ST-133 with the 70 V Shutter option cannot be used with a camera having the 25 mm shutter or the 40 mm shutter, even by selecting a different number, because the shutter could be permanently damaged by the high drive voltage and larger stored energy required to drive the 35 mm shutter. Note that the shutter is not covered by the warranty.

Overheating

Larger shutters do not normally exhibit thermal overloading, so they do not require the thermal interlock used by small shutters.

Making the Coolant Circulator-Detector Connections**Caution**

1. Do not use any coolant fittings other than those supplied by Princeton Instruments. Although standard pipefittings are similar, in most cases they are not the same. Forcing these fittings into the cooling block will permanently damage the threads.
2. VersArray cameras with liquid-assisted cooling or liquid-only cooling require circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation.
3. Take care that the coolant used is pH neutral. Acidic or alkaline coolant can damage the camera fittings and internal cooling block through corrosion. Such damage could be very expensive to repair.
4. Coolant should be no colder than +15°C to prevent condensation at 50% relative humidity. Operating a VersArray detector with coolant at a colder temperature could cause induced condensation in the electronics enclosure and possible catastrophic damage to the detector. ***Damage resulting from this type of operation may void the warranty.***

1. Set up the coolant circulator according to the directions in the user manual for that equipment. Do not apply power to the circulator until directed to do so.
2. Make the hose connections between the circulator and the detector. For best cooling performance, the tubing should be no longer than necessary. Connection directions are provided for two tubing sizes. Follow the directions appropriate to your camera.
 - a. **1/4" Connections:** Use 1/4", thin-wall plastic tubing. Be sure the tubing is properly secured at both ends. Note that the ports on this camera use a ferrule-less quick-disconnect method of securing the tubing and that both the camera's valve

body and the fitting insert include automatic shutoff to prevent coolant leaks when disconnected.

To Secure the Tubing:

For best cooling, connect the inflow and outflow tubing to the ports as indicated in Figure 24.

- 1) Remove the retaining nuts for the fitting and slide them over the outside of the plastic tubing.
 - 2) Slide the tubing over the barb on the fitting.
 - 3) Slide the retaining nuts to the end of the tubing and tighten them to the threads of the fitting.
 - 4) Insert the fitting into the appropriate valve body (Inlet or Outlet) until you hear a click.
 - 5) Then insert the fitting at the other end of the tubing into the appropriate port on the coolant circulator. You should hear a click, which indicates that the fitting is latched in place.
 - 6) Because of the automatic shutoffs, disconnecting the coolant supply is done by simply depressing the release tabs (Figure 24) and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.
- b. **3/8" Connections:** Use 3/8" I.D., thick-wall PVC tubing. Hose clamps secure the tubing to the male quick-disconnects.

To Secure the Tubing:

For best cooling, connect the inflow and outflow tubing to the ports as indicated in Figure 24.

- 1) Insert the male quick-disconnect (on tubing) into the appropriate female quick-disconnect on the camera (Inlet or Outlet) until you hear a click.
- 2) Then insert the fitting at the other end of the tubing into the appropriate port on the coolant circulator. You should hear a click, which indicates that the fitting is latched in place.
- 3) Because of the automatic shutoffs, disconnecting the coolant supply is done by simply depressing the release tabs (Figure 24) and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.

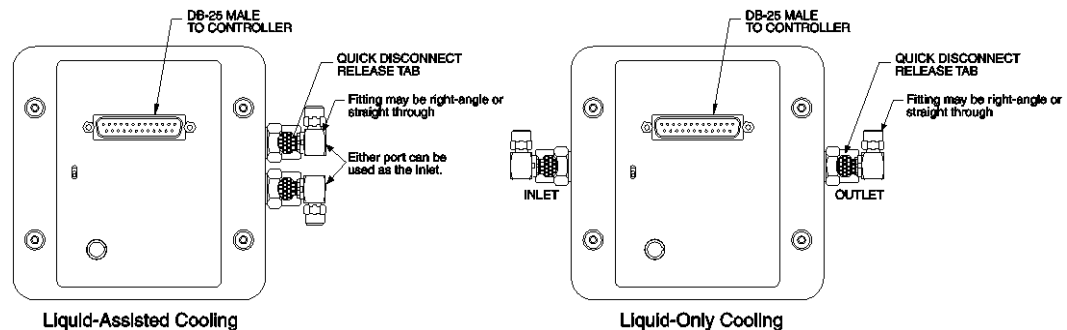


Figure 24. Coolant Ports

Recommended Flow Rate and Fluid Pressure

Flow Rate: 2 liters/minute. Users are advised to install a flow meter to monitor the rate.

Fluid Pressure: 25 psig (maximum).

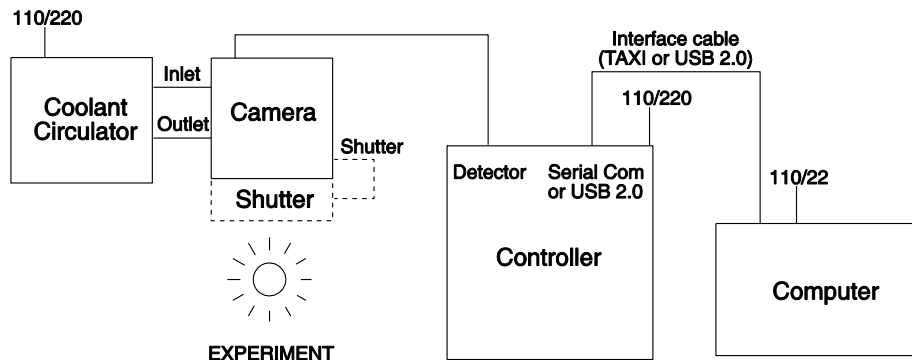


Figure 25. System Diagram: Air-Assist/Liquid-Assist TE Camera with Coolant Circulator

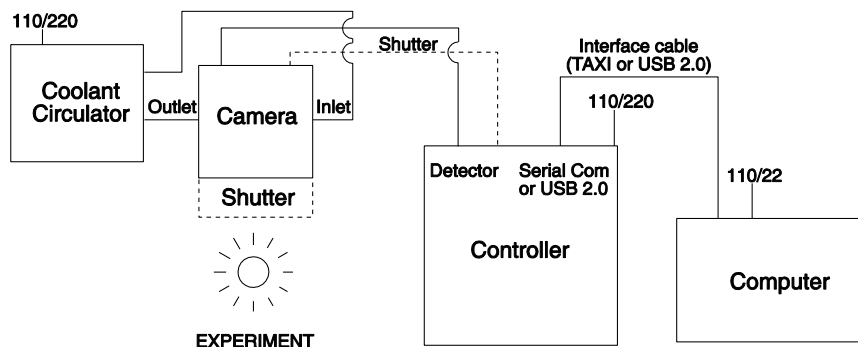


Figure 26. System Diagram: Liquid-Cooled TE Camera with Coolant Circulator

Filling the Dewar (LN-cooled Detectors)

DANGER

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.

1. Verify that the system has been turned on and that the application software is running.
2. Set the detector temperature to -100°C
3. Assuming that the camera has been properly evacuated, loosen the retaining nut (Figure 27) a few turns, then remove the LN Dewar port cap by pulling it straight out.

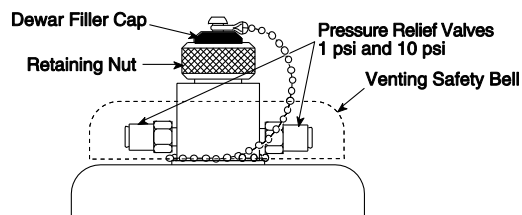


Figure 27. Dewar Ports and Valves

It is recommended that an LN transfer Dewar with a pouring spout be used to transfer LN from the storage tank to the camera. If you are going to use a funnel, place a thin vent tube into the Dewar through the funnel to reduce splashing due to boiling LN.

4. Pour approximately 100 ml of LN into the Dewar. Stop for 5-10 minutes until you observe a "geyser-like" vapor burst from the Dewar opening. This burst is normal and has to do with reaching a thermal equilibrium between the LN and the Dewar container surfaces.
5. Fill up the Dewar (approximately 1.7 liters for standard Dewar or 0.75 liters for an all-directional Dewar). To test the LN level, insert a straight piece of wire (a cryogenic "dip stick") into the Dewar briefly, then remove it. The LN level will be indicated by the condensation on the wire.
6. Once the Dewar has been filled, replace the filler cap and hand-tighten the retaining nut by giving it about 3/4 turn (or more) beyond the point where the nut feels snug.

WARNING!

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

7. Once a temperature of -80°C has been achieved, maintain the CCD at that temperature for 2-3 hours, then reset the dial to the desired temperature. This procedure prevents any residual water vapor (if introduced during shipment or through erroneous pumping in your lab, e.g., if your trap is inefficient) from condensing on the CCD window.

If the Dewar is continuously refilled, this procedure is unnecessary and the dial can be set at the desired temperature without the intermediate -80°C stage.

Note: The pressure relief valves (Figure 27) underneath the protective covering will occasionally emit a plume of N_2 gas and mist. *Continuous* hissing indicates that the vacuum in the Dewar jacket is probably inadequate. In this case, *first remove all LN from the Dewar*, then reconnect the camera to the vacuum pump.

The cooler status indicator will turn from orange to green to indicate that the temperature is thermostated to within $\pm 0.050^{\circ}\text{C}$. For an LN-cooled CCD to reach -100°C normally requires 45-55 minutes.

Note: Temperature regulation does not reach its ultimate stability for at least 30 minutes after the green indicator LED has turned on. After this period of time the desired temperature is maintained with great precision.

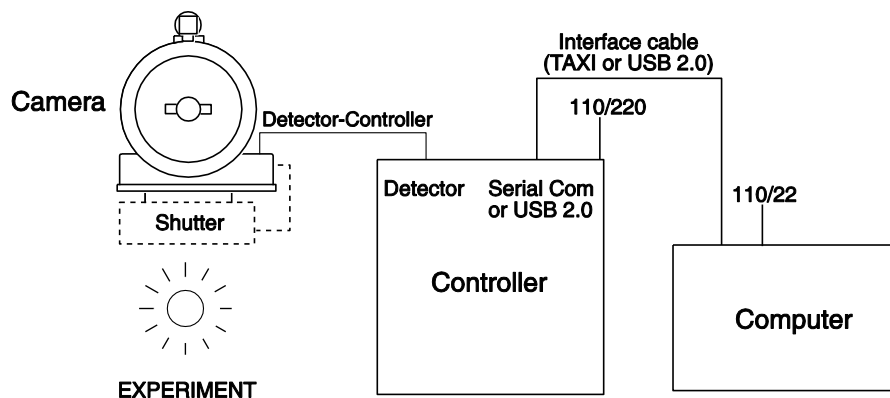


Figure 28. System Diagram: LN-cooled Camera

Dewar Options

Also available is the "all-directional" Dewar. An all-directional Dewar can operate in *any* angular orientation but hold only about approximately 0.85 liters, roughly half as much LN as the side-looking and end-looking Dewars. This reduced capacity translates to half the hold time as well.

Note: There is no simple way to verify whether you have been shipped an all-directional system simply by observing the camera. If you are uncertain, check the shipping paperwork to verify that your Dewar is an all-directional model.

For operation of the all-directional Dewar in a 90° orientation you can refill the Dewar only through a special 90° funnel provided by Princeton Instruments. For operation at greater than 90° angles, there is only one refilling choice: the Dewar must be returned to a 0° (upright) orientation for refilling.

ATTENTION

It is generally good practice to turn on the controller and start at least one data collection while the camera is cooling down, and then to keep the controller in operation for the entire time the Dewar contains LN₂. This will establish and maintain the "keep cleans" mode of the controller so that, even when the CCD is not actively taking data, it will be continuously cleaning (shifting charge on the array to clear dark charge and cosmic ray artifacts).

Introduction

LN-cooled cameras use liquid nitrogen to reduce the temperature of the CCD. The liquid nitrogen is stored in a Dewar that is enclosed in a vacuum jacket for minimal external thermal losses. The chip temperature is regulated by closed-loop proportional control circuitry. A thermal sensing diode attached to the cooling block of the camera monitors the chip temperature. The range depends on the CCD device (see Table 5).

CCD Model	Approx. Range
512F	-70°C to -120°C
1300B/F	-70°C to -110°C
2048B/F	-70°C to -110°C

Table 5. Approximate Temperature Range vs. CCD

Caution

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

Holding Times

At its lowest operating temperature, Princeton Instrument's large capacity Dewar (1.7 liters) has a hold time of 25 hours or more in an upright position. However, the hold time will vary depending on the Dewar orientation, array size, and operating temperature.

To maximize the holding time when leaving the camera overnight, in addition to topping off the Dewar, you will want to set the array temperature to its lowest operating temperature (-120°C or -110°C , depending on the array size) via the Detector Temperature dialog box in the WinView software. *You must leave the controller power on to prevent potential damage due to excessively cold temperatures.* The effect of setting the array temperature to its lowest operating temperature is to reduce the heating of the array and thereby minimize LN evaporation. The following day, reset the camera temperature to the array's operating temperature.

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Operation

Introduction

Once the VersArray camera has been installed, camera operation is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32 or WinSpec/32), set the target detector temperature, wait until the temperature has stabilized at the set temperature (see the "*Setting the Temperature*" section in this chapter), and then do actual data acquisition in the **Acquire** mode. Additional considerations regarding experiment setup and equipment configuration are addressed in the software manual.

During data acquisition, the CCD array is exposed to a source and charge accumulates in the pixels. After the defined exposure time, the accumulated signal is readout of the array, digitized, and then transferred to the host computer. Upon data transfer, the data is displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in Figure 29.

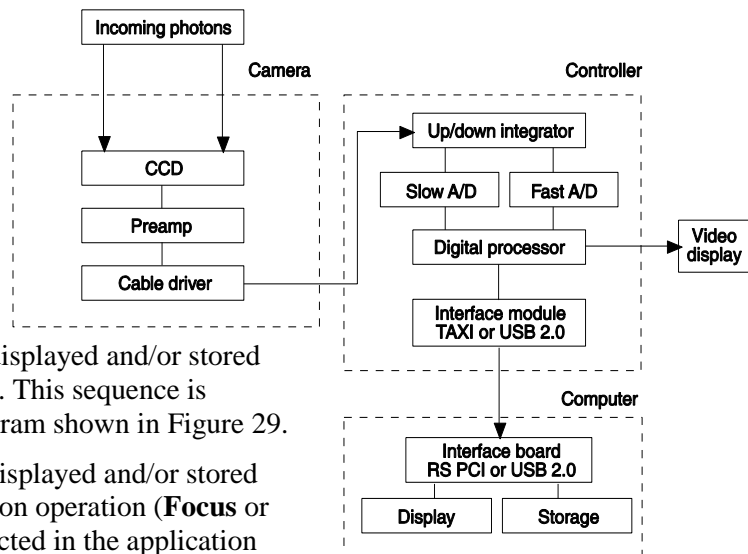


Figure 29. Block Diagram of Light Path in System

Whether or not the data is displayed and/or stored depends on the data collection operation (**Focus** or **Acquire**) that has been selected in the application software. In WinView and WinSpec, these operations use the Experiment Setup parameters to establish the exposure time (the period when signal of interest is allowed to accumulate on the CCD). As might be inferred from the names, **Focus** is more likely to be used in setting up the system (see the "*First Light*" discussions) and **Acquire** is then used for the collection and storage of data. Briefly:

- In **Focus** mode, the number of frames and accumulations settings are 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. Only the last frame acquired before Stop is selected can be stored. When Stop is selected, the File Save function can be used to save the currently displayed data. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.
- In **Acquire** mode, every frame of data collected can be automatically stored (the completed dataset may include multiple frames with one or more accumulations).

This mode would ordinarily be selected during actual data collection. One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow will eventually occur. This could only happen in Fast Mode operation.

The remainder of this chapter is organized to first talk about the system on/off sequences. Then "*First Light*" procedures for imaging and spectroscopy applications follow: these procedures provide step-by-step instruction on how to initially verify system operation. The last three sections discuss factors that affect exposure, readout, and digitization of the incoming signal. By understanding these factors and making adjustments to software settings you can maximize signal-to-noise ratio. For information about synchronizing data acquisition with external devices, please refer to *Chapter 6, Advanced Topics*.

USB 2.0 System On/Off Sequences

If your system is configured for the USB 2.0 communication interface, you must follow the system on/off sequences as stated below. These sequences ensure that communication is established and maintained between the camera and the host computer:

1. The VersArray camera must be powered ON before WinView/32 or WinSpec/32 is opened to ensure communication between the camera and the computer. If WinView or WinSpec is opened and the VersArray is not powered ON, many of the functions will be disabled and you will only be able to retrieve and examine previously acquired and stored data. You must close WinView or WinSpec, power the camera ON, and reopen WinView or WinSpec before you can set up experiments and acquire new data.
2. WinView/32 or WinSpec/32 must be closed before powering the camera OFF. If you power the camera OFF before closing WinView or WinSpec, the communication link with the camera will be broken. You can operate the program in a playback mode (i.e., examine previously acquired data) but will be unable to acquire new data until you have closed WinView or WinSpec, powered the camera ON, and then re-opened WinView or WinSpec.

First Light (Imaging)

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

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapters 3 and 4.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is air-cooled.
5. The system is being operated in imaging mode.

6. The target is a sharp image, text, or a drawing that can be used to verify that the camera is "seeing" and can be used to maximize focus.

Warnings

WARNING

Before You Start, if your system includes a microscope Xenon or Hg arc lamp, it is **CRITICAL** to turn off all electronics adjacent to the arc lamp, especially your digital camera system and your computer hardware (monitors included) before turning on the lamp power.

Powering up a microscope Xenon or Hg arc lamp causes a large EMF spike to be produced that can cause damage to electronics that are running in the vicinity of the lamp. We advise that you place a clear warning sign on the power button of your arc lamp reminding all workers to follow this procedure. While Princeton Instruments has taken great care to isolate its sensitive circuitry from EMF sources, we cannot guarantee that this protection will be sufficient for all EMF bursts. *Therefore, in order to fully guarantee the performance of your system, you must follow this startup procedure.*

Getting Started

1. Mount a test target in front of the camera.
2. Turn on the controller power.

Note: With USB 2.0, the controller must be turned on before WinView/32 or WinSpec/32 is opened and WinView/32 or WinSpec/32 must be closed before the controller is turned off.

3. Turn on the computer power.
4. Start the application software.
5. Start the coolant flow or fill the LN Dewar.
6. Block light from the lens.

Setting the Parameters

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

Set the software parameters as follows:

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

Controller|Camera tab page (Setup|Hardware): Because the **Camera Detection wizard (Hardware Setup wizard** for earlier software version) installed default values appropriate for your system, verify the settings on this page. To reload the defaults, you click on the **Load Defaults From Controller** button on this tab page to load the default settings.

- **Use PVCAM:** For software versions 2.5.19.0 and lower, verify that the box is checked if you are using the USB 2.0 interface.
Note: This check box is not present on software versions 2.5.19.6 and higher.
- **Controller type:** ST-133
- **Controller version:** 3 or higher
- **Camera type:** Select the array installed in your camera.
- **Shutter type:** None, Large, or Remote (system dependent).
- **Readout mode:** Full frame.

Detector Temperature (Setup|Detector Temperature...): -40°C for air-cooled. To see when the array temperature reaches and stabilizes at the target temperature, leave the Detector Temperature dialog box open. When the target temperature is reached, the dialog box will report that the Current Temperature has **Locked** and the **Temp Lock** LED on the back of the ST-133 will light to indicate that the temperature is thermostated to within 0.25°C.

Notes:

1. Some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction.
2. If you are using the USB 2.0 interface, the Detector Temperature dialog box will not display temperature information while you are acquiring data.

Interface tab page (Setup|Hardware): High Speed PCI (or PCI(Timer))

Note: This tab page is not available if you are using the USB 2.0 interface.

Cleans and Skips tab page (Setup|Hardware): Default

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

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

Experiment Setup ROI tab page (Acquisition|Experiment Setup...):

Use this function to define the region of interest (ROI).

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

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

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

Acquiring Data

1. If you are using WinView/32 and the computer monitor for focusing, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired.
2. Adjust the lens aperture, intensity scaling, and focus for the best image as viewed on the computer monitor. Some imaging tips follow:
 - Begin with the lens blocked off and then set the lens at the smallest possible aperture (largest f-stop number).
 - Make sure there is a suitable target in front of the lens. An object with text or graphics works best. If working with a microscope, use any easily viewed specimen.
 - Adjust the intensity scaling and lens aperture until a suitable setting is found. The initial intensity scaling setting of 4096 assures that the image won't be missed altogether but could be dim. Once you've determined that the image is present, select a lower setting for better contrast. Check the brightest regions of the image to determine if the A/D converter is at full-scale. *A 12-bit A/D is at full scale when the brightest parts of the image reach an intensity of 4095.* Adjust the aperture to where it is just slightly smaller (higher f-stop) than the setting where maximum brightness on any part of the image occurs.
 - Set the focus adjustment of the lens for maximum sharpness in the viewed image.
 - In the case of a camera with an F-mount, the camera lens adapter itself also has a focus adjustment. If necessary, this focus can be changed to bring the image into range of the lens focus adjustment. See "*F-Mount Adapter Focusing Procedure*", page 127.
3. After you have focused the camera, you can stop **Focus** mode, continue **Focus** mode, begin **Acquire** mode, or wait for the CCD to reach the operating temperature before going to **Acquire** mode.
4. If the array is cooled by LN, empty the Dewar before turning off the controller. If a coolant circulator or a chiller/circulator unit is being used to cool the array, stop the flow before turning off the controller.

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

First Light (Spectroscopy)

The following paragraphs provide step-by-step instructions for placing your spectroscopy system in operation the first time. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed. An underlying assumption for the procedure is that the detector is to be operated with a spectrograph such as the Acton SpectraPro™ 300i (SP300i) on which it has been properly installed. A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapters 3 and 4.
2. You have read the previous sections of this chapter.
3. You are familiar with the application software.
4. The system is air-cooled.
5. The system is being operated in spectroscopy mode.
6. An entrance slit shutter is not being controlled by the ST-133.

Getting Started

1. Set the spectrometer entrance slit width to minimum (10 μm if possible).
2. Power ON the spectrograph (i.e., switch the power supply ON).
3. Turn on the controller power.

Note: With USB 2.0, the controller must be turned on before WinView/32 or WinSpec/32 is opened and WinView/32 or WinSpec/32 must be closed before the controller is turned off.

4. Turn on the computer power.
5. Start the application software.
6. Start the coolant flow or fill the LN Dewar.

Setting the Parameters

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

Set the software parameters as follows:

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

Controller|Camera tab page (Setup|Hardware): Because the **Camera Detection wizard (Hardware Setup wizard** for earlier software version) installed default values appropriate for your system, verify the settings on this page. To reload the defaults, you click on the **Load Defaults From Controller** button on this tab page to load the default settings.

- **Use PVCAM:** For software versions 2.5.19.0 and lower, verify that the box is checked if you are using the USB 2.0 interface.

Note: This check box is not present on software versions 2.5.19.6 and higher.

- **Controller type:** ST-133
- **Controller version:** 3 or higher
- **Camera type:** Select the array installed in your detector.
- **Shutter type:** None or Remote.
- **Readout mode:** Full frame.

Detector Temperature (Setup|Detector Temperature...): -40°C for air-cooled. To see when the array temperature reaches and stabilizes at the target temperature, leave the Detector Temperature dialog box open. When the target temperature is reached, the dialog box will report that the Current Temperature has **Locked** and the **Temp Lock** LED on the back of the ST-133 will light to indicate that the temperature is thermostated to within 0.25°C.

Notes:

1. Some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction.
2. If you are using the USB 2.0 interface, the Detector Temperature dialog box will not display temperature information while you are acquiring data.

Interface tab page (Setup|Hardware): High Speed PCI (or PCI(Timer))

Note: This tab page is not available if you are using the USB 2.0 interface.

Cleans and Skips tab page (Setup|Hardware): Default

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

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

Experiment Setup ROI tab page (Acquisition|Experiment Setup...):

Use this function to define the region of interest (ROI).

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

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

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

Focusing

The mounting hardware provides two degrees of freedom, focus and rotation. In this context, focus means to physically move the detector back and forth through the focal plane of the spectrograph. The approach taken is to slowly move the detector in and out of focus and adjust for optimum while watching a live display on the monitor, followed by rotating the detector and again adjusting for optimum. The following procedure, which describes the focusing operation with an Acton 300I spectrograph, can be easily adapted to other spectrographs.

1. Mount a light source such as a mercury pen-ray type in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.
2. With the spectrograph properly connected to the controller, turn the power on, wait for the spectrograph to initialize. Then set it to 435.8 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

Hint: Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrograph. Select 435.833 as the spectral line.

3. Set the slit to 25 μm . *If necessary, adjust the Exposure Time to maintain optimum (near full-scale) signal intensity.*
4. In WinView, select **Focus** (on the **Acquisition** menu or on the **Experiment Setup** dialog box) to begin data accumulation. Data will be continuously acquired and displayed but will not be stored until **Start Store** is selected. At that time, data collection stops and the last frame taken will be stored.
5. Slowly move the detector in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Leave the detector set for the narrowest achievable line. You may want to use the **Focus Helper** function (**Process|Focus Helper...**) to determine the narrowest line width: it can

automatically locate peaks and generate a report on peak characteristics during live data acquisition (see the WinSpec/32 on-line help for more information).

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

- **Long focal-length spectrographs such as the Acton 300i:** 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, either provided by the spectrograph or by the mounting hardware, then the only recourse will be to adjust the spectrograph's focusing mirror.
6. Next adjust the rotation. You can do this by rotating the detector while watching a live display of the line. The line will go from broad to narrow and back to broad. Leave the detector rotation set for the narrowest achievable line.

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

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

Exposure and Signal

Introduction

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

CCD Array Architecture

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

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

Exposure Time

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

For some CCD arrays, the VersArray camera uses a mechanical shutter to control exposure of the CCD. The diagram in Figure 30 shows how the exposure period is measured. The NOT SCAN signal at the **SCAN** BNC on the back of the ST-133 can be used to monitor the exposure and readout cycle (t_R). This signal is also shown in Figure 30. The value of t_c is shutter type dependent, and will be configured automatically for ST-133 controllers shipped with an internal shutter.

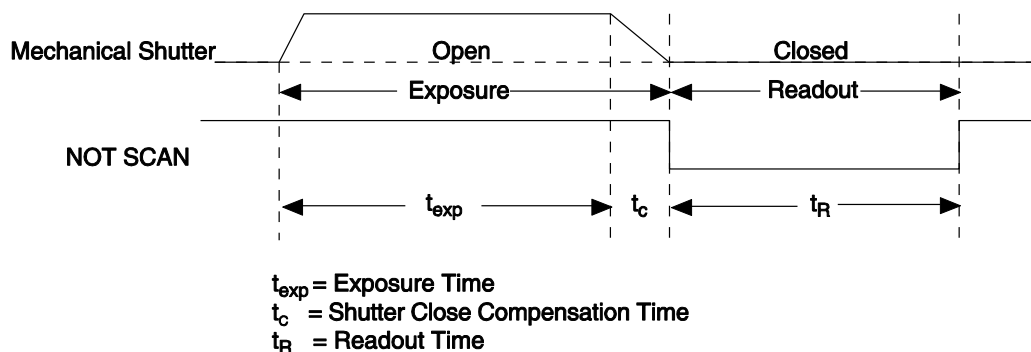
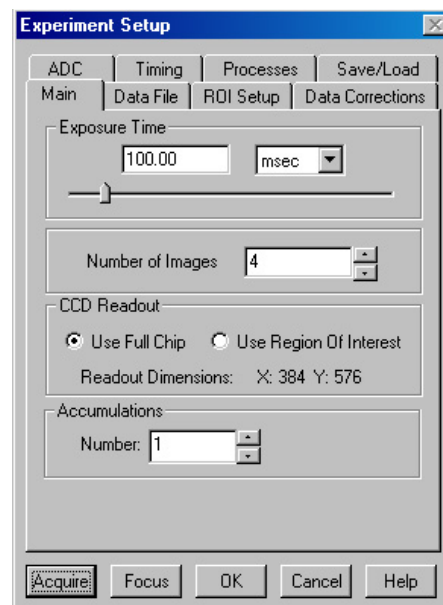


Figure 30. Exposure of the CCD with Shutter Compensation

Note that NOT SCAN is low during readout, high during exposure, and high during shutter compensation time.

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

Continuous Exposure (No Shuttering)

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

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

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

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

Cooling the CCD

Cameras in the VersArray family can be either thermoelectrically- or cryogenically-cooled. The thermoelectrically-cooled cameras feature cost-effective performance, ease of use, and cooling from +20°C to as low as -60°C. Cooling performance depends on whether the array chamber is backfilled or evacuated and whether the TE-cooling is air-assisted, liquid-assisted, or is liquid cooled. With cryogenic cooling, VersArray controllers provide stabilized temperature control of LN cameras from -70 to -120°C (-70°C to -110°C for large arrays). Generally speaking, the lower the array temperature, the lower the dark current and, therefore, the greater the sensitivity.

The temperature control mechanism used in a TE-cooled camera chills the array. The temperature control mechanism in an LN-cooled camera heats the array. Because the temperature of LN is -196°C and the operating temperature of the array is in the range of -70°C to -120°C, it is essential that an LN-cooled camera be connected to an operating controller before LN is poured into the Dewar and while there is LN remaining in the Dewar. This prevents potential damage to the array by excessive cold or saturation of the CCD.

Note: Temperature regulation does not reach its ultimate stability for at least 30 minutes after temperature lock is established.

Cautions

1. The VersArray camera requires the ST-133 Controller that has been shipped with it. Do not use a controller for a TE-cooled system with an LN-cooled camera. Do not use a controller for an LN-cooled system with a TE-cooled camera.
2. LN-cooled CCDs, because of their low operating temperatures, must *always* be connected to an operating controller. If the controller power is turned off with liquid nitrogen remaining in the Dewar, the CCD will quickly become saturated with charge, which cannot be readily removed without warming the camera to room temperature. It is generally good practice to turn on the controller and start at least one data collection while the camera is cooling down, and then to keep the controller in operation for the entire time the Dewar contains liquid nitrogen. This will establish and maintain the "keep cleans" mode of the controller so that, even when the CCD is not actively taking data, it will be continuously cleaning (shifting charge on the array to clear dark charge and cosmic ray artifacts).

CCD Temperature Control

As stated before, lowering the temperature of the CCD will generally enhance the quality of the acquired signal. When WinView or WinSpec is the controlling software, temperature control is done via the **Detector Temperature** dialog box (see Figure 31) accessed from the **Setup** menu. Once the target array temperature has been set, the software controls the circuits in the camera so the array temperature is reduced (thermoelectrically-cooled operation) or the array temperature is raised (cryogenically-cooled operation) to the set value. On reaching that temperature, the control loop locks to that temperature for stable and reproducible performance.

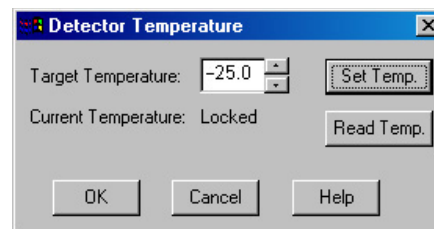


Figure 31. WinView/WinSpec Detector Temperature dialog box

When temperature lock has been reached (temperature within 0.25°C of set value) the Detector Temperature dialog box reports that the current temperature is **Locked**. This on-screen indication allows easy verification of temperature lock. In addition, the TEMP LOCK indicator on the back of the controller lights GREEN to indicate that lock has been achieved (for more information, refer to the description of the ST-133 rear panel features, page 18).

The deepest operating temperature for a system depends on the CCD array size, the CCD packaging, and the type of cooling; and the time required to achieve lock can vary over a considerable range, depending on such factors as the camera type, CCD array type, ambient temperature, etc. (see Table 11, on page 110, for typical deepest cooling temperatures). Once lock occurs, it is okay to begin focusing. However, you should wait an additional twenty minutes before taking quantitative data so that the system has time to achieve optimum thermal stability.

Note: If you are using the USB 2.0 interface, the Detector Temperature dialog box will not display temperature information while you are acquiring data.

ADC Offset (Bias)

With the camera completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger this background will appear. This background can be dealt with in a couple of ways: background subtraction, in which a background image is acquired and then subtracted from an illuminated image, or by offsetting the baseline so that much of the background is ignored during analog-to-digital conversion (ADC).

The baseline offset is a voltage that is added to the signal to bring the A/D output to a non-zero value, typically 50-100 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the A/D "0" value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 (16-bit ADC) to a value in the range of 50-100 counts lower.

Notes:

1. Do not be concerned about either the DC level of this background or its shape unless it is very high (i.e., > 1000 counts for LN-cooled or > 400 counts for TE-cooled). What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Every device has been thoroughly tested to ensure its compliance with Princeton Instruments' demanding specifications.

2. The baseline can be adjusted by using the F and S Zero pots located on the rear panel of the controller. If these pots are not present, the baseline may be software-adjustable.
3. Do not adjust the offset values to zero or some low-level data will be missed.

CAUTION

If you observe a sudden change in the baseline signal you may have excessive humidity in the vacuum enclosure of the detector. Turn off the controller (if LN-cooled, remove the liquid nitrogen also) and *contact Princeton Instruments Customer Support. See page 150 for contact information.*

Dark Charge

Dark charge (or dark current) is the thermally induced buildup of charge in the CCD over time. The statistical noise associated with this charge is known as dark noise. Dark charge values vary widely from one CCD array to another and are exponentially temperature dependent. Dark charge effect is more pronounced in the case of cameras having a non-MPP array.

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

Notes:

1. Do not be concerned about either the DC level of this background or its shape unless it is very high, i.e., > 1000 counts with 16-bit ADC or 300 counts with a 12-bit ADC. What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Simply acquire and save a dark charge "background image" under conditions identical to those used to acquire the "actual" image. Subtracting the background image from the actual image will significantly reduce dark-charge effects.
2. Offset and excess noise problems are more likely to occur if the controller and camera weren't calibrated and tested as a system at the factory.

CAUTION

If you observe a sudden change in the baseline signal, you may have excessive humidity in the camera's vacuum enclosure. Immediately turn off the system and contact Princeton Instruments Customer Support for instructions. *See page 150 for contact information.*

Saturation

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

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

Readout

Introduction

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

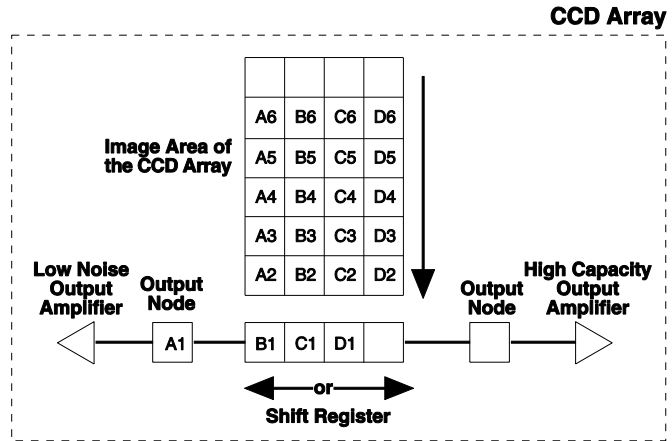


Figure 32. Array Terms for a CCD with Dual Output Amplifiers

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

Full Frame

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

The upper left drawing in Figure 33 represents a CCD after exposure but before the beginning of readout. The capital letters represent different amounts of charge, including both signal and dark charge.

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

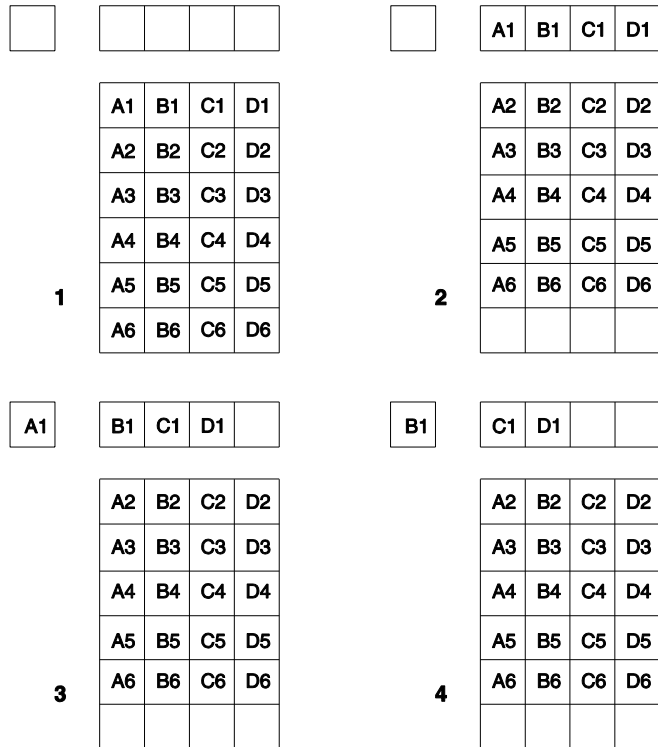


Figure 33. Full Frame at Full Resolution

Readout of the CCD begins with the simultaneous shifting of all pixels one row toward the "shift register," in this case the

row at the top. The shift register is a single line of pixels along one edge of the CCD, not sensitive to light and used for readout only. Typically the shift register pixels hold twice as much charge as the pixels in the imaging area of the CCD.

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

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

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

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

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

where

t_R is the CCD readout time,

t_{exp} is the exposure time, and

t_c is the shutter compensation time (added to compensate for the time required to close a mechanical shutter). If there is no shutter selected in the software, this time will be approximately 0 ms.

The readout time is approximately given by:

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

where

N_x is the smaller dimension of the CCD

N_y is the larger dimension of the CCD

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

t_v is the time needed to digitize a pixel

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

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

Binning

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

Hardware Binning

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

Binning also reduces readout time and the burden on computer memory, but at the expense of resolution. Since shift register pixels typically hold only twice as much charge as image pixels, the binning of large sections may result in saturation and "blooming", or spilling of charge back into the image area.

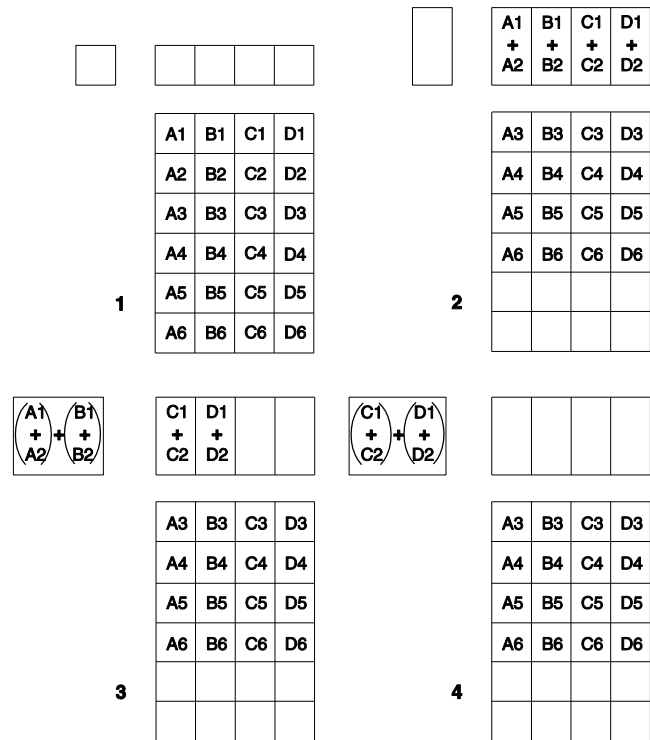


Figure 34. 2 x 2 Binning for Images

Figure 34 shows an example of 2 x 2 binning. Each pixel of the image displayed by the software represents 4 pixels of the CCD array. Rectangular bins of any size are possible.

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

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

Software Binning

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

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

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

Software averaging can improve the S/N ratio by as much as the square-root of the number of scans. Unfortunately, with a high number of scans (i.e., above 100) camera 1/f noise may reduce the actual S/N ratio to slightly below this theoretical value. Also, if the

light source used is photon flicker ($1/f$ noise) limited rather than photon shot-noise limited, this theoretical signal improvement cannot be fully realized. Again, background subtraction from the raw data is necessary.

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

Output Amplifier Selection

VersArray systems with dual output amplifiers allow you to choose the array output amplifier (High Capacity or Low Noise) via WinView/32 or WinSpec/32 on the **Acquisition|Experiment Setup...|Main** tab page. The High Capacity amplifier selection provides a spectrometric well capacity that is approximately 3 times the well capacity for the Low Noise amplifier selection. High Capacity is suitable when you have intense light signals or signals with high dynamic range. The Low Noise amplifier provides highest sensitivity performance and is suitable when you have weak signals.

Note: The choice of output amplifier and analog gain setting should be considered together for the best signal capture.

Analog Gain Control

Camera (analog) gain is software-selectable in many of the VersArray cameras. In WinView/32 and WinSpec/32, gain selection is made on the **Acquisition|Experiment Setup...|ADC** tab card. If there is no Analog Gain parameter on that tab card, analog gain may not be selectable or it may be controlled by a gain switch on the detector, as is the case with older TE- and LN-cooled cameras (see Figure 35).

Note: When software-selection of Analog Gain is available, this selection will override any hardware setting that may be selected at the camera.

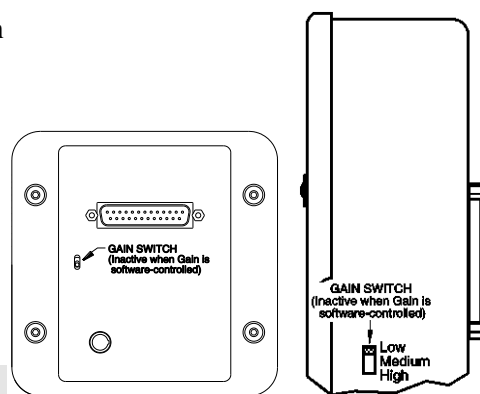


Figure 35. Analog Gain Switch on TE- and LN-cooled Cameras

Analog gain control is used to change the number of electrons required to generate an Analog-to-Digital Unit (ADU, also known as a count). In WinView/32 and WinSpec/32, the analog gain choices vary depending on the CCD array and the number of output amplifiers:

- **Single Amplifier:** Typically, three settings are available: Low 2x, Medium 1x, and High 1/2x.
- **Dual Amplifier:** Typically, three settings are available: Low 2x, Medium 1x, and High 1/2x (Low-noise mode) or Low 4x, Medium 2x, and High 1x (High-capacity mode).

Users who measure high-level signals may wish to select **Low** to allow digitization of larger signals. At **Medium** gain, the detector has typically been calibrated so the overall noise is ~ 1 ADU RMS. This setting is suitable for experiments within the mid-level intensity range. Users who consistently measure low-level signals may wish to select **High**, which requires fewer electrons to generate an ADU and reduces some sources of noise. This is a particularly important consideration in absorbance measurements.

Example: The following descriptions assume that the actual incoming light level is identical in all three instances. *The numbers used illustrate the effect of changing an analog gain setting and do not reflect actual performance: gain at the Low, Medium, and High settings depends on the CCD installed.*

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

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

High requires two 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 CCD array appears to be flooded with light, you may want to change the setting to **Medium** or **Low**.

Note: The baseline level may require adjustment if you change the analog gain. See "*ADC Offset*", page 66, for more information.

Digitization

Introduction

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts that analog information (continuous amplitudes) into a digital data (quantified, discrete steps) that can be read, displayed, and stored by the application software. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software (see "*Readout*", page 68).

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

Digitization Rate

Depending on the VersArray system, single, dual (100 kHz/1 MHz or 50kHz/1 MHz), or multiple digitization rates may be available.

Dual and multiple digitization rates provide optimum signal-to-noise ratios at all readout speeds. Because the readout noise of CCD arrays increases with the readout rate, it is sometimes necessary to trade off readout speed for high dynamic range. In the most common ST-133 configurations, there will be a 1 MHz conversion speed for the fastest possible data collection and a 100 kHz or 50 kHz conversion speed for use where noise performance is the paramount concern. With the VersArray XP systems, up to six digitization rates are available. Switching between the conversion speeds is completely under software control for total experiment automation.

Note: In WinView and WinSpec, the ADC rate can be changed on the **Experiment Setup|ADC** tab page.

Advanced Topics

Introduction

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization (set up on the **Experiment Setup|Timing** tab page in WinView and WinSpec), TTL control, and the Kinetics mode option.

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

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

"TTL Control", the third topic, discusses the **TTL IN/OUT** connector on the rear of the ST-133. TTL In/Out levels can be set and read via the WinX32 Automation language to automate data acquisition and processing functions.

"Kinetics Mode", the final topic, discusses the Kinetics mode option. This form of data acquisition relies on mechanical or optical masking of the CCD array for acquiring time-resolved images/spectra.

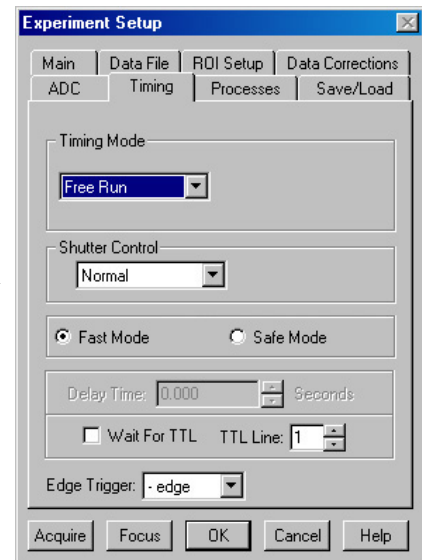


Figure 36. Timing tab page

Timing Modes

Overview

The Princeton Instruments ST-133 Controller has been designed to allow the greatest possible flexibility when synchronizing data collection with an experiment.

The chart to the right lists the timing mode combinations (selected on the **Experiment Setup|Timing** tab page). These timing modes are combined with the Shutter options to provide the widest variety of timing modes for precision experiment synchronization.

The shutter options available include Normal, PreOpen, Disable Opened or Disable Closed. Disable simply means that the shutter will not operate during the experiment. Disable closed is useful for making dark charge measurements, or when no shutter is present. PreOpen, available in the External Sync and External Sync with Continuous Cleans modes, opens the shutter as soon as the ST-133 is ready to receive an External Sync pulse. This is required if the time between the External Sync pulse and the event is less than a few milliseconds, the time it takes the shutter to open.

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

The timing diagrams are labeled indicating the exposure time (t_{exp}), shutter compensation time (t_c), and readout time (t_R). For more information about these parameters, see the discussion of frame readout, starting on page 68.

Free Run

In the Free Run mode the controller does not synchronize with the experiment in any way. The shutter opens as soon as the previous readout is complete, and remains open for the exposure time, t_{exp} . Any External Sync signals are ignored. This mode is useful for experiments with a constant light source. Other experiments that can utilize this mode are high repetition studies, where the number of shots that occur during a single shutter cycle is so large that it appears to be continuous illumination.

Other experimental equipment can be synchronized to the ST-133 controller by using the output signal (software-selectable **SHUTTER** or **NOT SCAN** on the **Hardware Setup|Controller/Camera** tab page) from the **SCAN** connector. Shutter operation and the **NOT SCAN** output signal are shown in Figure 38.

Mode	Shutter
Free Run	Normal
External Sync	Normal
External Sync	PreOpen
External Sync with Continuous Cleans	Normal
External Sync with Continuous Cleans	PreOpen

Table 6. Camera Timing Modes

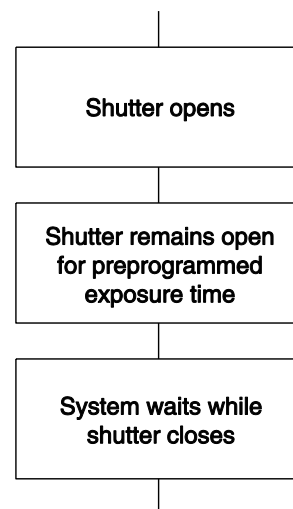


Figure 37. Free Run Timing Chart, part of the chart in Figure 43

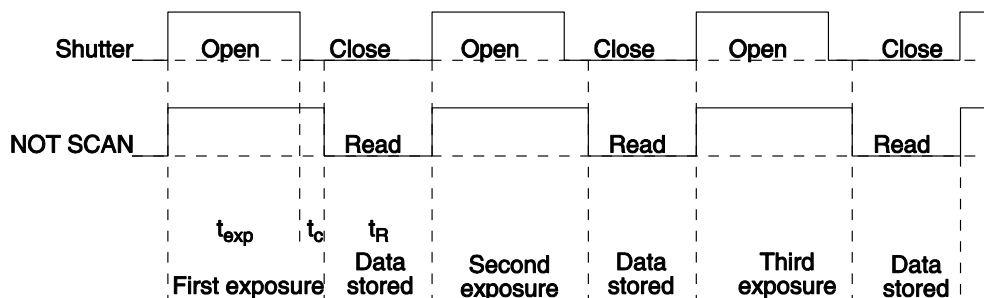


Figure 38. Free Run Timing Diagram

External Sync

In this mode all exposures are synchronized to an external source via signal input to the **EXT SYNC** BNC on the back of the ST-133. To ensure synchronization, the trigger edge (negative- or positive-going as set in the software) of the Ext Sync signal must be identified in the application software (in WinView and WinSpec, this is done on the **Experiment Setup|Timing** tab page). As shown in the flowchart, Figure 39, External Sync mode can be used in combination with Normal or PreOpen Shutter operation. In Normal Shutter mode, the controller waits for an External Sync pulse trigger edge, then opens the shutter for the programmed exposure period. As soon as the exposure is complete, the shutter closes and the CCD array is read out.

Because the external shutter requires a finite amount of time to open completely (shutter open time may be 5-28 msec depending on the shutter), the External Sync pulse trigger edge provided by the experiment should precede the actual signal by at least that much time. If not, the shutter may not be open for the duration of the entire signal, or the signal may be missed completely.

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

In the PreOpen Shutter mode, on the other hand, shutter operation is only partially synchronized to the experiment. As soon as the controller is ready to collect data, the shutter opens. Upon arrival of the first External Sync pulse trigger edge at the ST-133 **EXT SYNC** BNC, the shutter remains open for the specified exposure period, closes, and the CCD is read out. As soon as readout is complete, the shutter reopens and waits for the next frame.

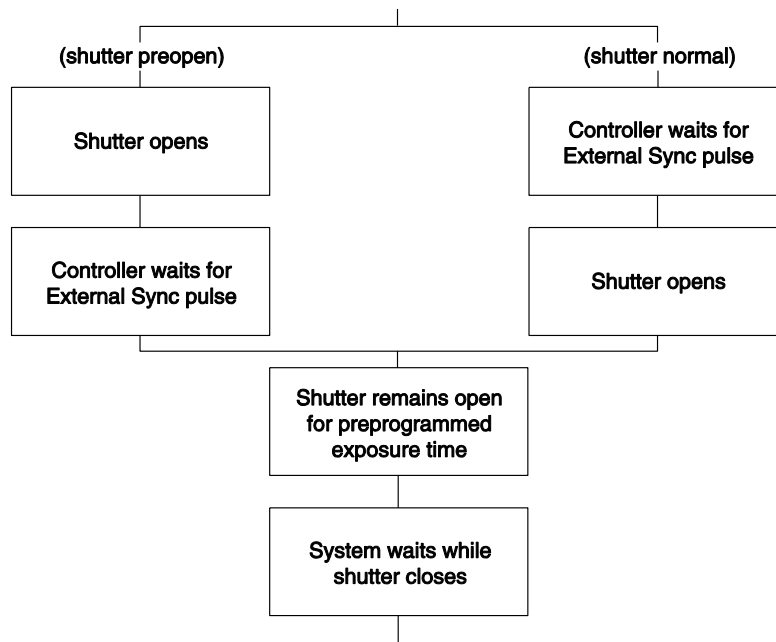


Figure 39. Chart Showing Two External Sync Timing Options

The PreOpen mode is useful in cases where an External Sync pulse trigger edge cannot be provided 5-28 msec (shutter open time) before the actual signal occurs. Its main drawback is that the CCD is exposed to any ambient light while the shutter is open between frames. If this ambient light is constant, and the triggers occur at regular intervals, this background can also be subtracted, providing that it does not saturate the CCD. As with the Normal Shutter mode, accurate background subtraction may not be possible for the first frame.

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

Note: If EXT SYNC is still active (in Figure 40, these means that if it is still **LOW**) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

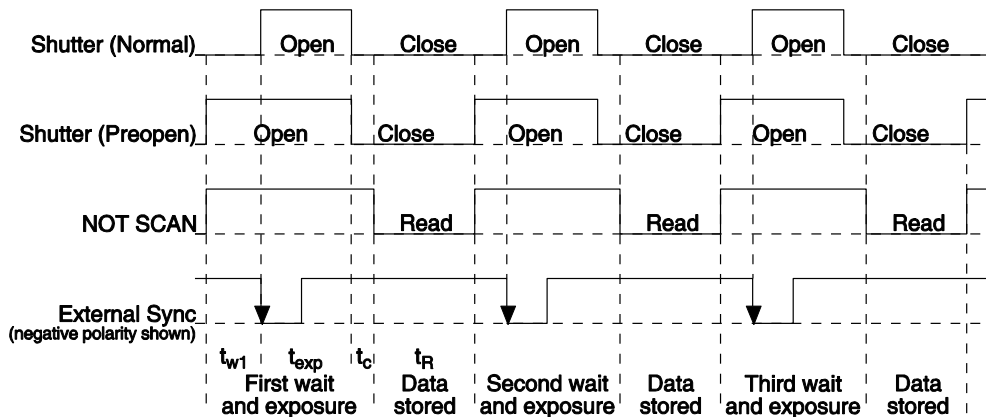


Figure 40. Timing Diagram for External Sync Mode (- edge trigger)

External Sync with Continuous Cleans

Another timing mode available with the ST-133 controller is called Continuous Cleans. In addition to the standard "cleaning" of the array, which occurs after the controller is enabled, Continuous Cleans will remove any charge from the array until the moment the External Sync pulse trigger edge is received.

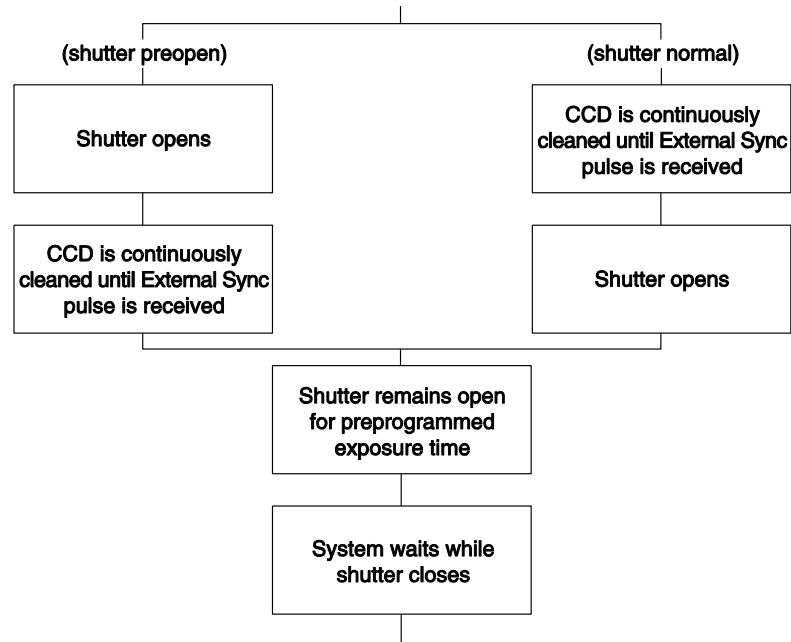


Figure 41. Continuous Cleans Operation Flowchart

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

Note: If EXT SYNC is still active (in Figure 42, these means that if it is still LOW) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

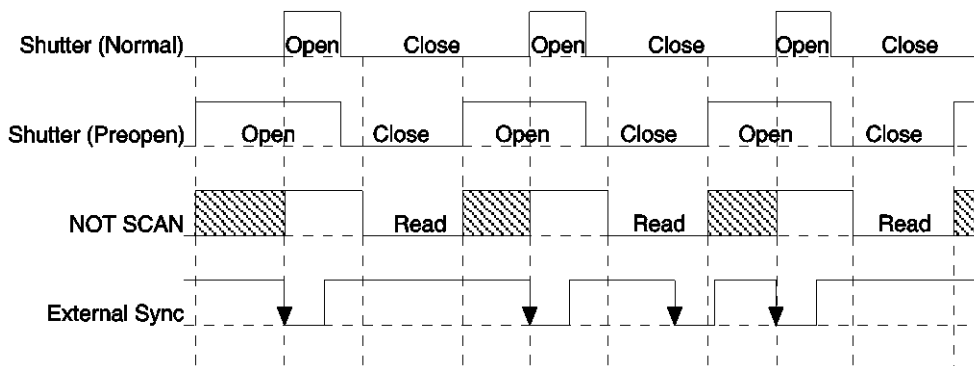


Figure 42. Continuous Cleans Timing Diagram (- edge trigger)

Fast Mode and Safe Mode

The WinView/32 **Experiment Setup|Timing** tab page allows you to choose **Fast Mode** or **Safe Mode**. Figure 43 is a flow chart comparing the two modes. In Fast Mode operation, the ST-133 runs according to the timing of the experiment, with no interruptions from the computer. In Safe Mode operation, the computer processes each frame as it is received. The ST-133 cannot collect the next frame until the previous frame has been completely processed.

Fast Mode operation is primarily for collecting "real-time" sequences of experimental data, where timing is critical and events cannot be missed. Once the ST-133 is sent the Start Acquisition command by the computer, all frames are collected without further intervention from the computer. The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the computer will only display frames when it is not performing other tasks. Image display has a lower priority, so the image on the screen may lag several images behind. A second drawback is that a data overrun may occur if the number of images collected exceeds the amount of allocated RAM or if the computer cannot keep up with the data rate.

Safe Mode operation is primarily useful for experiment setup, including alignment and focusing, when it is necessary to have the most current image displayed on the screen. It is also useful when data collection must be coordinated through software with external devices such as external shutters and filter wheels. As seen in Figure 43, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the computer sends the Stop Acquisition command to the camera, instructing it to stop acquisition. Once that frame is completely processed and displayed, another Start Acquisition command is sent from the computer to the camera, allowing it to take the next frame. Display is therefore, at most, only one frame behind the actual data collection.

One disadvantage of the Safe Mode is that events may be missed during the experiment, since the ST-133 is disabled for a short time after each frame.

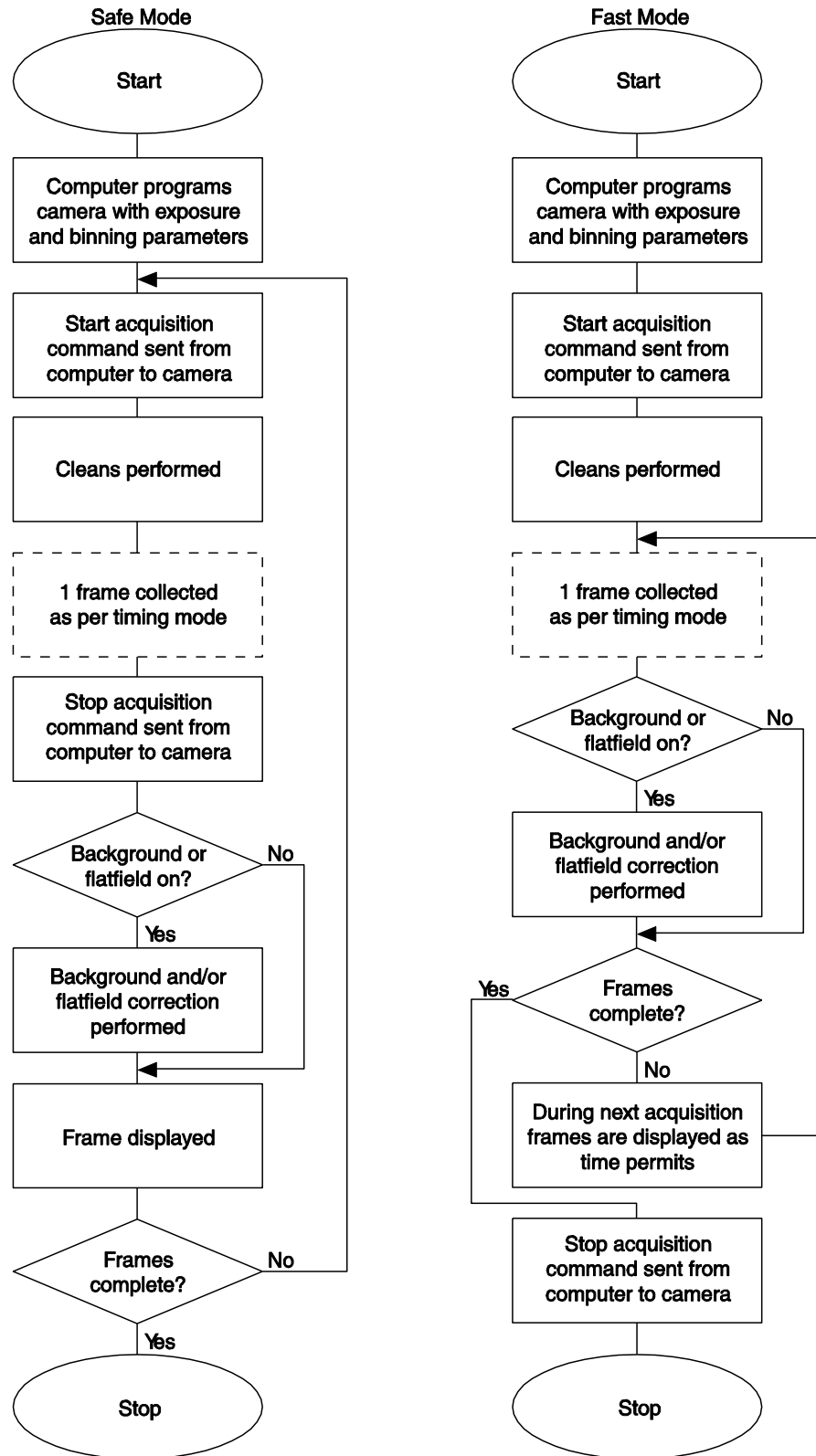


Figure 43. Chart of Safe and Fast Mode Operation

TTL Control

Fully supported by WinView/WinSpec Version 2.5 when the communication protocol is TAXI (PCI), this feature is not supported when the protocol is USB 2.0.

Introduction

Princeton Instruments' WinView/32 (WinSpec/32) software package incorporates WinX32 Automation, a programming language that can be used to automate a variety of data acquisition and data processing functions, including use of the TTL In/Out functions. WinX32 Automation can be implemented in programs written in Visual Basic or Visual C++. See the WinX32 documentation for more detailed information.

The TTL lines are made available through the TTL In/Out connector on the rear of the ST-133 Controller. This connector provides 8 TTL lines in, 8 TTL lines out and an input control line. Figure 44 illustrates the connector and Table 8 lists the signal/pin assignments.

TTL In

The user controls the 8 TTL Input lines, setting them high (+5 V; TTL 1) or low (0 V; TTL 0). When the lines are read, the combination of highs and lows read defines a decimal number which the computer can use to make a decision and initiate actions as specified in the user's program. If a TTL IN line is low, its numeric value is 0. If a TTL IN line is high, its numeric value is as follows.

TTL IN	Value	TTL IN	Value
1	1	5	16
2	2	6	32
3	4	7	64
4	8	8	128

This coding allows any decimal value from 0 to 255 to be defined. Thus, as many as 256 different sets of conditions can be specified, at the user's discretion, using the TTL IN lines. *Any unused lines will default to TTL high (+5 V).* For example, to define the number three, the user would simply set the lines TTL IN 1 and TTL IN 2 both high (+5 V). It would be necessary to apply TTL low to the remaining six lines because they would otherwise default to TTL high as well.

TTL IN	Value	TTL IN	Value
1	High (1)	5	Low (0)
2	High (2)	6	Low (0)
3	Low (0)	7	Low (0)
4	Low (0)	8	Low (0)

Table 7 illustrates this coding for decimal values 0 through 7. Obviously this table could easily be extended to show the coding for values all the way to 255.

Decimal Equiv.	TTL IN/OUT 8 1= dec 128	TTL IN/OUT 7 1=dec 64	TTL IN/OUT 6 1=dec 32	TTL IN/OUT 5 1=dec 16	TTL IN/OUT 4 1=dec 8	TTL IN/OUT 3 1=dec 4	TTL IN/OUT 2 1=dec 2	TTL IN/OUT 1 1=dec 1
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	1	1
4	0	0	0	0	0	1	0	0
5	0	0	0	0	0	1	0	1
6	0	0	0	0	0	1	1	0
7	0	0	0	0	0	1	1	1

Table 7. Bit Values with Decimal Equivalents:
1 = High,
0 = Low

Buffered vs. Latched Inputs

In controlling the TTL IN lines, users also have the choice of two input-line states, *buffered* or *latched*. In the buffered state, the line levels must remain at the intended levels until they are read. With reference to the preceding example, the high level at TTL IN 1 and TTL IN 2 would have to be maintained until the lines are read. In the latched state, the applied levels continue to be available until read, even if they should change at the TTL In/Out connector.

This control is accomplished using the EN/CLK TTL input (pin 6). If EN/CLK is open or high, *buffered* operation is established and the levels reported to the macro will be those in effect when the READ is made. With reference to our example, if pin 6 were left unconnected or a TTL high applied, TTL IN 1 and TTL IN 2 would have to be held high until read. If, on the other hand, EN/CLK were made to go low while TTL IN 1 and TTL IN 2 were high, those values would be *latched* for as long as EN/CLK remained low. The levels actually present at TTL IN 1 and TTL IN 2 could then change without changing the value that would be read by software.

TTL Out

The state of the TTL OUT lines is set from WinView/32. Typically, a program monitoring the experiment sets one or more of the TTL Outputs. Apparatus external to the VersArray system interrogates the lines and, on detecting the specified logic levels, takes the action appropriate to the detected condition. The coding is the same as for the input lines. There are eight output lines, each of which can be set low (0) or high (1). The combination of states defines a decimal number as previously described for the TTL IN lines.

Pin #	Assignment	Pin #	Assignment
1	IN 1	14	IN 2
2	IN 3	15	IN 4
3	IN 5	16	IN 6
4	IN 7	17	IN 8
5	GND	18	GND
6	EN/CLK	19	Reserved
7	Reserved	20	GND
8	GND	21	OUT 2
9	OUT 1	22	OUT 4
10	OUT 3	23	OUT 6
11	OUT 5	24	OUT 8
12	OUT 7	25	GND
13	Reserved		

Table 8. TTL In/Out Connector Pinout

TTL IN/OUT

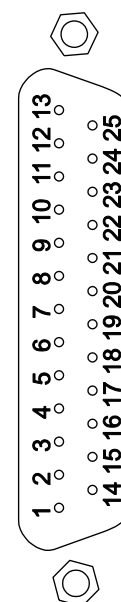


Figure 44. TTL In/Out Connector

TTL Diagnostics Screen

WinView/32 and WinSpec/32 provide a TTL Diagnostics screen (located under **Hardware Setup|Diagnostics**) that can be used to test and analyze the TTL In/Out lines.

Hardware Interface

A cable will be needed to connect the TTL In/Out connector to the experiment. The design will vary widely according to each user's needs, but a standard 25-pin female type D-subminiature connector will be needed to mate with the TTL In/Out connector on the back of the ST-133. The hardware at the other end of the cable will depend entirely on the user's requirements. If the individual connections are made using coaxial cable for maximum noise immunity

(recommended), the center conductor of the coax should connect to the proper signal pin and the cable shield should connect to the nearest available ground (grounds are conveniently provided at pins 5, 8, 18 and 20). Connector hardware and cables of many different types are widely available and can often be obtained locally, such as at a nearby Radio Shack® store. A list of possibly useful items follows. Note that, although the items listed may be appropriate in many situations, they might not meet your specific needs.

- 25-pin female type D-subminiature solder type connector (Radio Shack® part no 276-1548B).
- RG/58U coaxial cable.

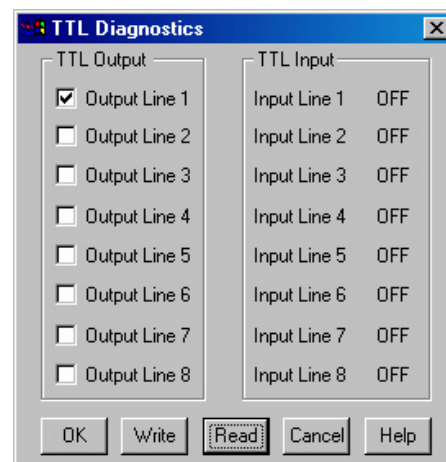


Figure 45. TTL Diagnostics dialog box

- Shielded Metalized hood (Radio Shack part no 276-1536A).
- BNC connector(s) type UG-88 Male BNC connector (Radio Shack part no 278-103).

Cable Assembly Example

Suppose you needed to build a cable to monitor the line TTL OUT 1. One approach would be to build a cable assembly as described in the following paragraphs. This procedure could easily be adapted to other situations.

1. Begin with a 25-pin female type D-subminiature solder type connector (Radio Shack part no 276-1548B). This connector has 25 solder points open on the back.
2. Referring to Table 8, note that pin 8 = GND and pin 9 = TTL OUT 1.
3. Using coaxial cable type RG/58U (6 feet length), strip out the end and solder the outer sheath to pin 8 (GND) and the inner line to pin 9 (TTL OUT 1). Then apply shielding to the lines to insulate them.
4. Mount the connector in a Shielded Metalized hood (Radio Shack part no 276-1536A).
5. Build up the cable (you can use electrical tape) to where the strain relief clamp holds.
6. Connect a BNC connector (UG-88 Male BNC connector) to the free end of the cable following the instructions supplied by Radio Shack on the box (Radio Shack part no 278-103).
7. To use this cable, connect the DB-25 to the TTL In/Out connector on the back of the ST-133.
8. To check the cable, start WinView/32 and open the TTL Diagnostics screen (located in WinView under **Hardware Setup|Diagnostics**). Click the **Write** radio button. Then click the **Output Line 1** box. Next click the **OK** button to actually set TTL OUT 1 high. Once you set the voltage, it stays until you send a new command.
9. Measure the voltage at the BNC connector with a standard voltmeter (red on the central pin, black on the surrounding shielding). Before clicking **OK** at the TTL Diagnostics screen you should read 0 V. After clicking **OK** you should read +5 V.

Note that adding a second length of coaxial cable and another BNC connector would be straightforward. However, as you increase the number of lines to be monitored, it becomes more convenient to consider using a multiple conductor shielded cable rather than individual coaxial cables.

Kinetics Mode

Kinetics operation requires that the Kinetics option has been installed. Additionally, WinView (or WinSpec), version 2.5.18.1 or higher, is required when operating under USB 2.0.

Introduction

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

Note: Kinetics mode is an option, so the controller must be programmed before your order is shipped. If the Kinetics option has been installed in the ST-133, this readout mode will be made available when you select the appropriate camera type on the **Hardware Setup** dialog box.

Below is a simplified illustration of kinetics mode. Returning to our 4×6 CCD example, in this case $2/3$ of the array is masked, either mechanically or optically. The shutter opens to expose a 4×2 region. While the shutter remains open, charge is quickly shifted just under the mask, and the exposure is repeated. After a third image is collected the shutter is closed and the CCD is read out. Since the CCD can be read out slowly, very high dynamic range is achieved. Shifting and readout are shown in Figure 46.

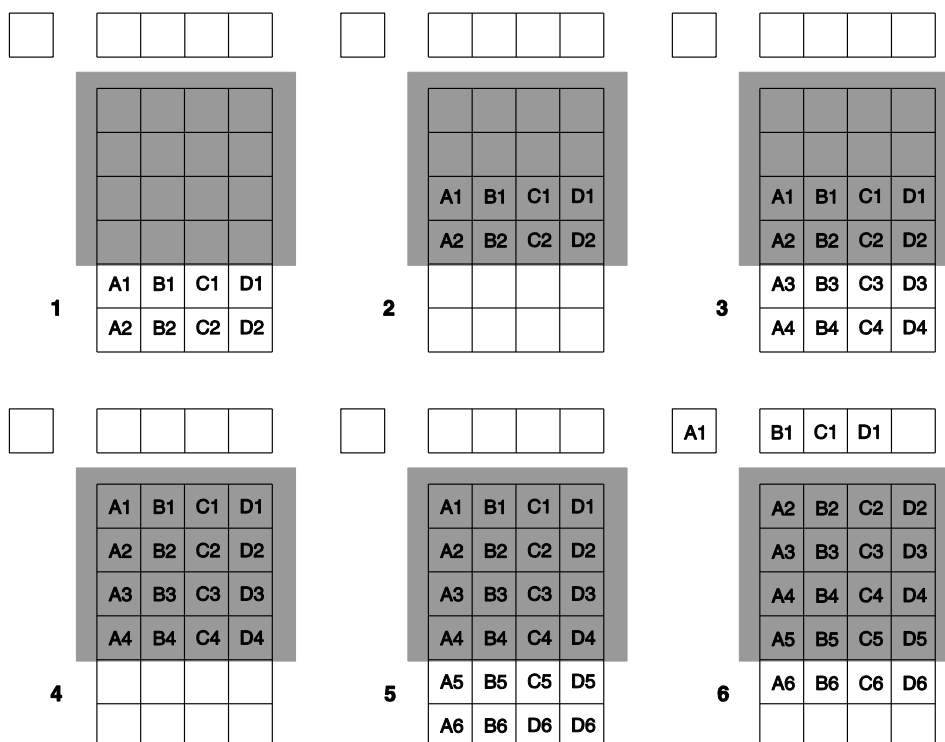


Figure 46. Kinetics Readout

Timing Modes

Kinetics mode operates with three timing modes: Free Run, Single Trigger, and Multiple Trigger.

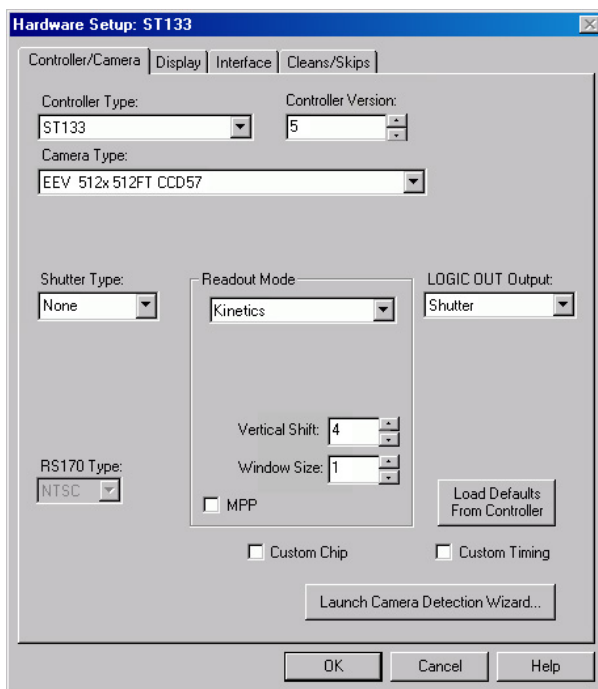


Figure 47. Hardware Setup dialog box

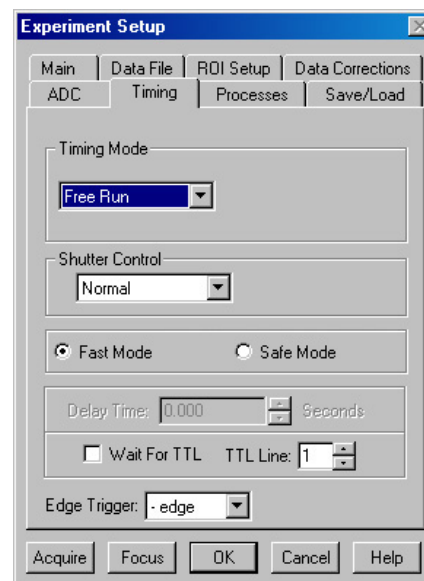


Figure 48. Experiment Setup dialog box

Free Run

In the Free Run Kinetics mode, the controller takes a series of images, each with the Exposure time set through the software (in WinSpec/32 or WinView/32, the exposure time is set on the **Experiment Setup|Main** tab page). The time between image frames, which may be as short as a few microseconds, is limited by the time required to shift an image under the mask: this interimage time equals the Vertical Shift rate (specified in $\mu\text{sec}/\text{row}$) multiplied by the Window Size (the number of rows allocated for an image frame). The exact number of frames depends on the selected Window Size and is equal to the number of pixels perpendicular to the shift register divided by the Window Size.

Example: Referring to the readout shown in Figure 46, there are 6 pixels perpendicular to the shift register and the Window Size is 2 pixels high. The number of frames is 3. If the Vertical Shift Rate for the CCD is $1.6 \mu\text{sec}/\text{row}$, the Shift time will be $3.2 \mu\text{sec}$ per frame. Integrate signals (**SHUTTER**) or Readout signals (**NOT SCAN**) are provided at the **SCAN** BNC for timing measurements

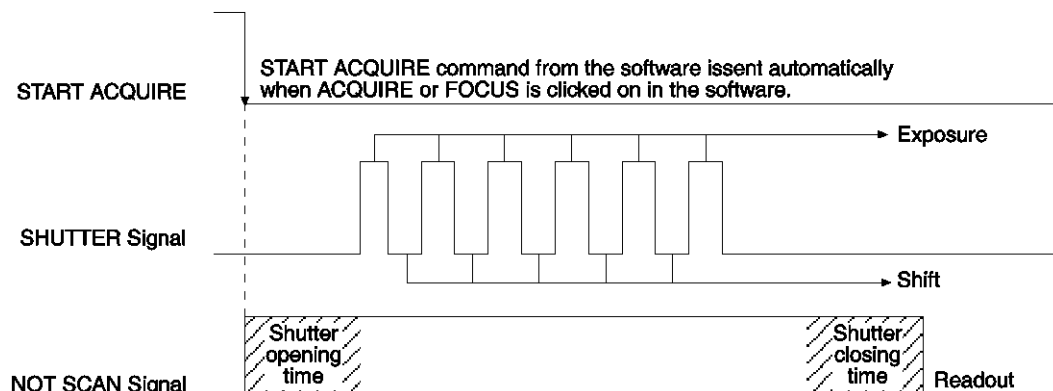


Figure 49. Free Run Timing Diagram

Single Trigger

Single Trigger Kinetics mode takes an entire series of images with each External Trigger Pulse (applied at the Ext. Sync BNC on the control board of ST-133). After the series is complete the shutter closes and the CCD is read out at normal speeds. Once the readout is complete the camera is ready for the next series of exposures. This timing is shown in Figure 50, where a single External trigger pulse is used to collect a burst of 6 frames.

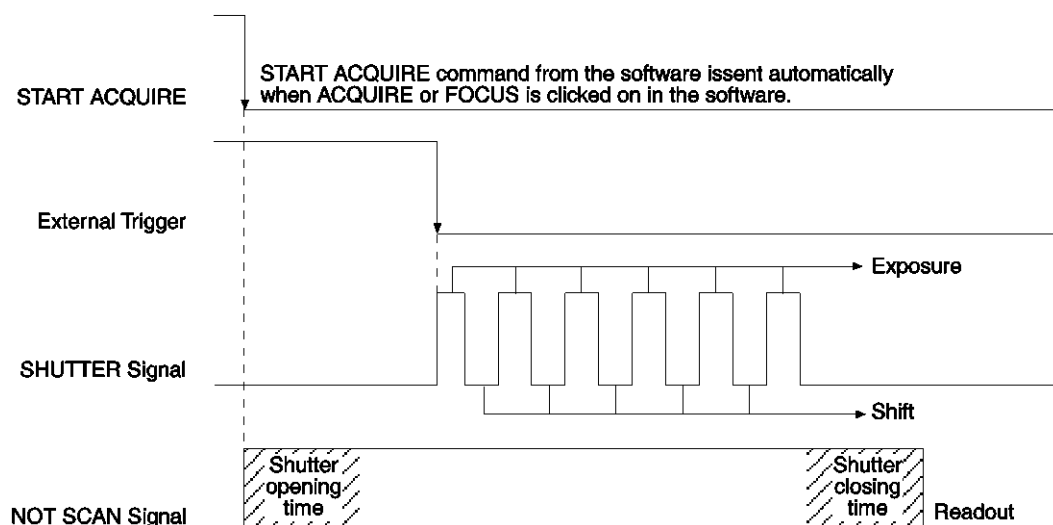


Figure 50. Single Trigger Timing Diagram

Multiple Trigger

Multiple Trigger Kinetics mode takes a single image in the series for each External Sync pulse received by the controller. Once the series is complete the shutter closes and readout begins. Since the shutter is open during the entire series of images, if the External Sync pulses are irregularly spaced then the exposures will be of different lengths. Once the series has been read out the camera is ready for the next series. This timing is shown in Figure 51, where a series of 6 frames is collected with 6 External Sync pulses.

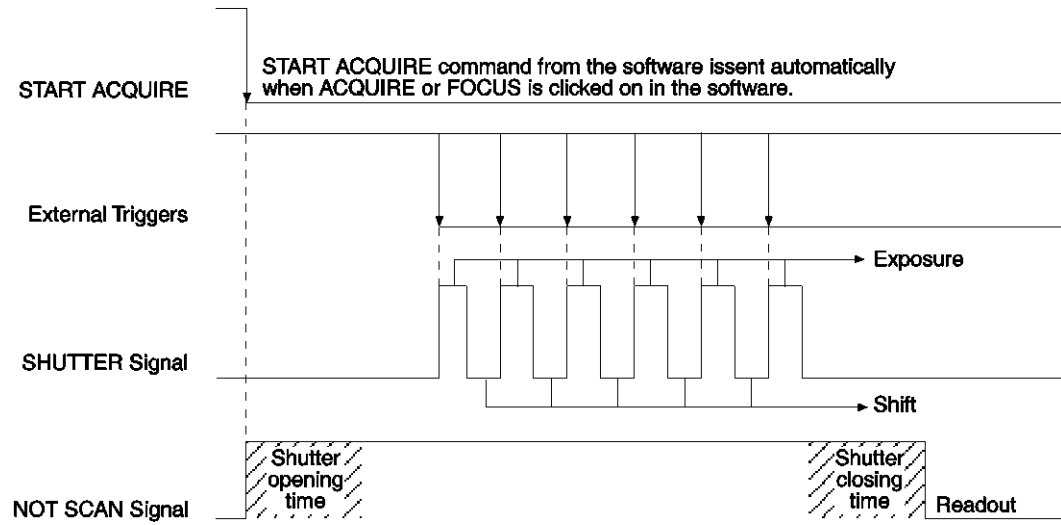


Figure 51. Multiple Trigger Timing Diagram

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Chapter 7

Troubleshooting

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

Introduction

The following issues have corresponding troubleshooting sections in this chapter.

Baseline Signal Suddenly Changes	Page 90
Camera Stops Working	Page 90
Camera1 (or similar name) in Camera Name field	Page 90
Changing the ST-133 Line Voltage and Fuses	Page 91
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Detector Temperature, Acquire, and Focus are Grayed Out (Versions 2.5.19.0 and earlier)	Page 98
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Error Occurs at Computer Powerup	Page 100
Excessive Readout Noise	Page 102
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Securing the Detector-Controller Cable Slide Latch	Page 106
Serial violations have occurred. Check interface cable.	Page 107
Shutter Failure	Page 107
Vignetting: LN-cooled Cameras	Page 107

Baseline Signal Suddenly Changes

A change in the baseline signal is normal if the temperature or gain setting has been changed. If this occurs when the temperature or gain setting has not been changed, contact Customer Support.

Camera Stops Working

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

- Turn off all AC power.
- Verify that all cables are securely fastened and that all locking screws are in place.
- Check for a burned-out fuse in the Controller power module. For information about changing a fuse, see "*Changing the ST-133's Line Voltage and Fuses*" on page 91.
- Correct any apparent problems and turn the system on.
- If you hear 2 clicks separated by 1 second (shutter opening then closing), the shutter is working. Call Princeton Instruments Customer Service for further instructions.

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

Camera1 (or similar name) in Camera Name field



Figure 52. Camera1 in Camera Name Field

When a PVCAM-based camera is detected/selected during the Camera Detection wizard (formerly the Hardware Setup wizard), a default name such as Camera1 will be shown in the Detected Hardware table and will be entered in the **Camera Name** field on the **Setup|Hardware|Controller/CCD** tab page. Because this name is not particularly descriptive, you may want to change it. Such a change is made by editing the PVCAM.INI file that is generated by Camera Detection wizard (or by the RSConfig.exe if you have a software version 2.5.19.0 or earlier).

To change the default Camera Name:

1. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\WINNT, for example). You should see entries like the ones below.

```
[Camera_1]
Type=1
Name=Camera1
Driver=apausb.sys
```

```
Port=0
ID=523459
```

- Change the "Name=" entry to something more meaningful for you (for example, ST133USB - to indicate that this is a PVCAM-based system using an ST-133 with a USB 2.0 interface) and save the edited file.

```
[Camera_1]
Type=1
Name=ST133USB
Driver=apausb.sys
Port=0
ID=523459
```

- The new camera name will now appear in the **Camera Name** field.

Changing the ST-133 Line Voltage and Fuses

The appropriate voltage setting for your country is set at the factory and can be seen on the power input module. If your voltage source changes, you will need to change the voltage setting and you may need to change the fuse configuration.

WARNING! Use proper fuse values and types for the controller and camera to be properly protected.

To Change Voltage and Fuse Configuration:

WARNING! Before opening the power input module, turn the Controller OFF and unplug the line cord.

- As shown in Figure 53, place the flat side of a flat bladed screwdriver parallel to the rear of the Controller and behind the small tab at the top of the power input module, and twist the screwdriver slowly but firmly to pop the module open.
- To change the voltage setting, roll the selector drum until the setting that is closest to the actual line voltage is facing outwards.

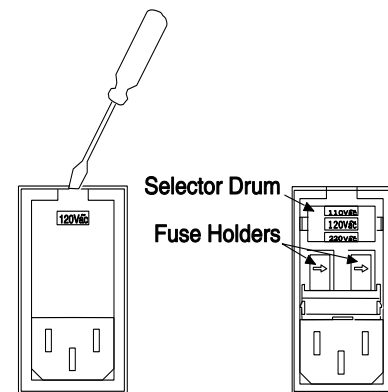


Figure 53. Power Input Module

- Confirm the fuse ratings by removing the two white fuse holders. To do so, simply insert the flat blade of the screwdriver behind the front tab of each fuse holder (Figure 54) and gently pry the assembly out.
- Refer to the Fuse/Voltage label (above or below the Power Module) to see which fuses are required by the selected voltage. If Controller power switch is on the back of the ST-133, the Fuse/Voltage label is located below the Power Module.



Figure 54. Fuse Holder

5. After inspecting and if necessary, changing the fuses to those required by the selected voltage, reinstall the holders with the arrow facing to the right.
6. Close the power input module and verify that the correct voltage setting is displayed.
7. Verify that the Controller power switch is in the OFF position and then plug the powercord back into the power input module.

Controller Is Not Responding

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

- If the Controller is ON, the problem may be with the interface card, its driver, interrupt or address conflicts, or the cable connections.
- If the interface card is not installed, close the WinX application program (WinView/32 or WinSpec/32) and turn the Controller OFF. Follow the interface card installation instructions in provided with your interface card and cable the card to the SERIAL COM port on the rear of the Controller. Then do a "Custom" installation of WinX application with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

Note: WinX applications (versions 2.6.0 and higher) do not support the ISA interface.

- If the interface card is installed in the computer and is cabled to the SERIAL COM port on the rear of the Controller, close the application program and turn the Controller OFF. Check the cable connections and tighten the locking screws if the connections are loose.
- If the interface card was installed after the application program was installed, close the application program and do a "Custom" installation of the WinX application with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

Note: WinX applications (versions 2.6.0 and higher) do not support the ISA interface.

Cooling Troubleshooting

Temperature Lock Cannot be Achieved or Maintained.

CAUTION

Operating a VersArray liquid-cooled-only camera with coolant at a temperature colder than specified could cause induced condensation in the electronics enclosure and possible catastrophic damage to the camera. ***Damage resulting from this type of operation may void the warranty.***

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

- Ambient temperature greater than +23°C. This condition primarily affects the TE-cooled cameras (air-assisted, liquid-assisted and liquid-cooled). If ambient is greater than +23°C, you will need to cool the camera environment or raise the set temperature.
- Airflow through the camera is blocked.
- The vacuum has deteriorated and needs to be refreshed.
- The connectors of the cable that interconnects the controller and the camera need to be secured.
- The target array temperature is not appropriate for your particular camera and CCD array.
- For cameras that are liquid-cooled or have liquid-assisted cooling, the coolant flow rate may be insufficient due to a pinched coolant line, blockages, circulator power problem, or pump failure. Check the flow rate and coolant temperature.
- For a TE camera, the camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. TE cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

Camera loses Temperature Lock

The internal temperature of the camera is too high. This might occur if the operating environment is particularly warm or if you are trying to operate at a temperature colder than the specified limit. If this happens, an internal thermal overload switch will disable the cooler circuits to protect them. Typically, camera operation is restored in about ten minutes. Although the thermal overload switch will protect the camera, users are advised to power down and correct the operating conditions that caused the thermal overload to occur. *With some versions of the software, the **indicated** temperature when the camera is in thermal overload (thermal switch is in the cut-out state) is -120° C.*

Gradual Deterioration of Cooling Capability

With time, there may be a gradual deterioration of the camera's vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. In the kind of applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's lowest temperature

performance because lower temperatures result in lower thermal noise and better the signal-to-noise ratio.

Vacuum deterioration occurs primarily as a result of material outgassing in the vacuum chamber. Because outgassing normally diminishes with time, the rate of vacuum deterioration in new cameras may be faster than in old ones. For example, a camera that has to be repumped after perhaps a year of operation, may not have to be pumped again for several years. In any case you may notice a gradual deterioration in temperature control performance indicative of vacuum deterioration. If this happens, the camera will have to be repumped. Contact the factory to make arrangements for returning the camera to the support facility nearest to you to have the vacuum restored.

Data Loss or Serial Violation

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

Data Overrun Due to Hardware Conflict message



Figure 55. Data Overrun Due to Hardware Conflict dialog box

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

To change the DMA buffer setting:

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

Data Overrun Has Occurred message

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

1. Minimize the number of programs running in the background while you are acquiring data with WinX application.
2. Run data acquisition in Safe Mode.
3. Add memory.
4. Use binning.
5. Increase the exposure time.
6. Defragment the hard disk.
7. Update the Orange Micro USB2 driver. See *"To Update the OrangeUSB 2.0 Driver"*, page 32.

If the problem persists, your application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user. However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If your experiment requirements include long data acquisition times and/or large data sets, your application may not be suitable for the USB 2.0 interface. Therefore, we recommend replacement of the USB 2.0 interface module with our TAXI interface module and Princeton Instruments (RSPI) high speed PCI card. If this is not the case and data overruns continue to occur, contact Customer Support (see page 150 for contact information).

Demo is only Choice on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)

If RSConfig.exe has not been run and there is not an installed Princeton Instruments (RSPI) high speed PCI card, the Hardware Setup wizard will only present the choice "Demo" in the Interface dialog box (Figure 56). Clicking on **Next** presents an "Error Creating Controller. Error=129." message, clicking on **OK** presents "The Wizard Can Not Continue Without a Valid Selection!" message, clicking on **OK** presents the Interface dialog box again.

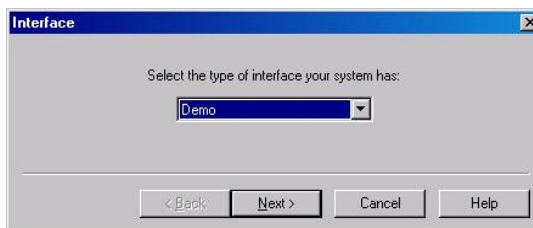


Figure 56. Hardware Wizard: Interface dialog box

At this point, you will need to exit the WinX application and run the RSConfig.exe program, which creates a file called PVCAM.INI. This file contains information required to identify the interface/camera and is referenced by the Hardware Setup wizard when you are setting up the WinX application with USB for the first time:

1. If you have not already done so, close the WinX application.
2. Make sure the ST-133 is connected to the host computer and that it is turned on.
3. Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed the WinX application.
4. When the RSConfig dialog box (Figure 57) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

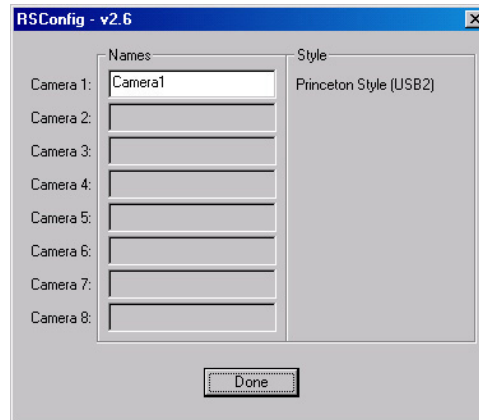


Figure 57. RSConfig dialog box

5. You should now be able to open the WinX application and, from **Setup|Hardware...**, run the Hardware Setup wizard.
6. When the PVCAM dialog box (Figure 58) is displayed, click in the **Yes** radio button, click on **Next** and continue through the wizard. After the wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to set up experiments and acquire data.

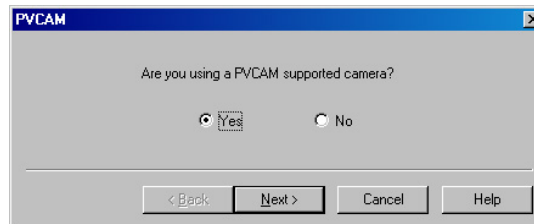


Figure 58. Hardware Wizard: PVCAM dialog box

Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)

If there is an installed Princeton Instruments (RSPI) high speed card in the host computer and you want to operate a camera using the USB 2.0 interface, the PVCAM.INI file (created by RSConfig.exe) must exist and the USB 2.0 supported camera must be [Camera_1]. PVCAM.INI, which contains information required to identify the interface/camera, is referenced by the Hardware Setup wizard when you are setting up the WinX application with USB for the first time. If the wizard did not find a PVCAM.INI file or if RSConfig.exe was run but the USB 2.0 camera is [Camera_2] in the

PVCAM.INI file, "Demo", "High Speed PCI", and "PCI(Timer)" will be selectable from the wizard's Interface dialog box.

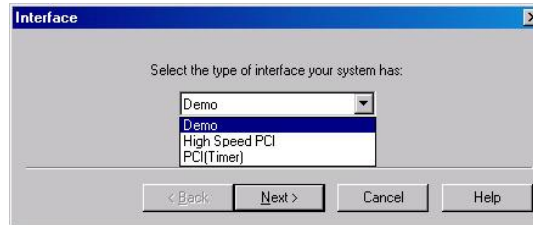


Figure 59. Hardware Wizard: Interface dialog box

At this point, you will need to run the RSConfig.exe program:

1. If you have not already done so, close the WinX application..
2. Make sure the ST-133 is connected to the host computer and that it is turned on.
3. Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed the WinX application.
4. When the RSConfig dialog box (Figure 60) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera2". When you have finished, click on the **Done** button.

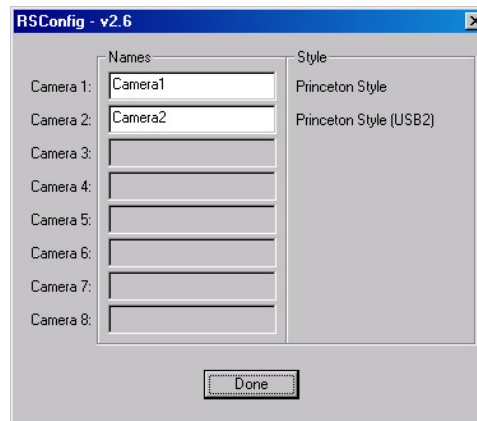


Figure 60. RSConfig dialog box: Two Camera Styles

5. Using **Notepad** or a similar text editor, open PVCAM.INI, which is located in the Windows directory (C:\WINNT, for example).

If the contents of the file look like: Change the headings so the contents now look like:

[Camera_1]	→	[Camera_2]
Type=1		Type=1
Name=Camera1		Name=Camera1
Driver=rspipci.sys		Driver=rspipci.sys
Port=0		Port=0
[Camera_2]	→	[Camera_1]
Type=1		Type=1
Name=Camera2		Name=Camera2
Driver=apausb.sys		Driver=apausb.sys
Port=0		Port=0

Note: The [Camera_#] must be changed so the camera supported by the USB interface will be recognized (the USB driver is "apausb.sys"). For consistency, you may also want to change the camera names.

6. Save the file. With the ST-133 connected and on, open the WinX application.
7. Run the Hardware Setup wizard.
8. When the PVCAM dialog box (Figure 61) is displayed, click in the **Yes** radio button, click on **Next** and continue through the wizard. After the wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to acquire data.

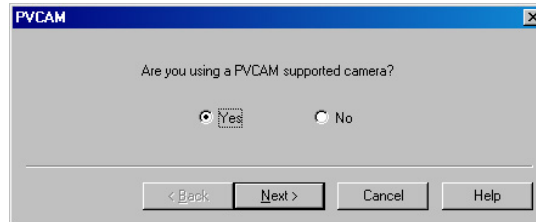


Figure 61. Hardware Wizard: PVCAM dialog box

Detector Temperature, Acquire, and Focus are Grayed Out (Versions 2.5.19.0 and earlier)

These functions and others will be deactivated if you have installed a camera being run under USB 2.0 and have opened the WinX application without having first turned on the ST-133. They will also be deactivated if you have installed a camera being run under USB 2.0 and a Princeton Instruments (RSPI) high speed PCI card was also detected when RSConfig.exe was run.

1. Check to see if the ST-133 is connected to the host computer and is turned on. If it is not connected or is connected but not turned on, go to Step 2. If it is connected and on, go to Step 3.
2. Close the WinX application, verify that the ST-133 is connected to the host computer, turn on the ST-133, and reopen the WinX application. The formerly grayed out functions should now be available.
3. If the ST-133 is connected and on, the USB 2.0 camera may not be listed as Camera 1 in the PVCAM.INI file.
4. Run RSConfig.exe (accessible from the **Windows|Start|Programs|PI Acton** menu). If the USB 2.0 camera is listed as Camera 2 (Princeton Style (USB2) in Figure 62), you will have to edit the PVCAM.INI file.

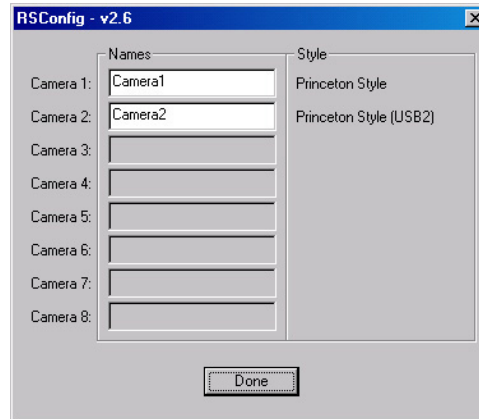


Figure 62. RSConfig dialog box: Two Camera Styles

- Using **Notepad** or a similar text editor, open PVCAM.INI, which is located in the Windows directory (C:\WINNT, for example).

If the contents of the file look like: Change the headings so the contents now look like:

[Camera_1]	→	[Camera_2]
Type=1		Type=1
Name=Camera1		Name=Camera1
Driver=rspipci.sys		Driver=rspipci.sys
Port=0		Port=0
[Camera_2]	→	[Camera_1]
Type=1		Type=1
Name=Camera2		Name=Camera2
Driver=apausb.sys		Driver=apausb.sys
Port=0		Port=0

Note: The [Camera_#] must be changed so the camera supported by the USB interface will be recognized (the USB driver is "apausb.sys"). For consistency, you may also want to change the camera names.

- Save the file. With the ST-133 connected and on, open the WinX application. The formerly grayed out functions should now be available.

Error Creating Controller message

This message may be displayed if you are using the USB 2.0 interface and have not run the RSConfig.exe program (see previous topic), if the PVCAM.INI file has been corrupted, or if the ST-133 was not turned on before you started the WinX application and began running the Hardware Setup wizard.

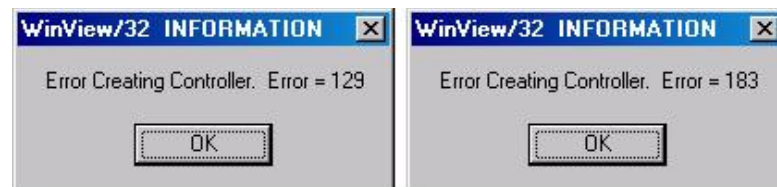


Figure 63. Error Creating Controller dialog box

Error 129: Indicates that the problem is with the PVCAM.INI file. Close the WinX application, run RSConfig, make sure the ST-133 is on, reopen the WinX application, and begin running the Hardware Setup wizard.

Error 183: Indicates that the ST-133 is off. If you are running the Hardware Setup wizard when this message appears, click on **OK**, turn on the ST-133, and, on the PVCAM dialog box, make sure **Yes** is selected and then click on **Next**. The Hardware Setup wizard should continue to the Controller Type dialog box.

Error Occurs at Computer Powerup

If an error occurs at boot up, either the Interface is not installed properly or there is an address or interrupt conflict. Turn off the computer, try a new address or interrupt and reinstall the card. Be sure the Interface is firmly mounted in the slot.

Caution Since interrupts and DMA channels cannot be shared, make sure no other boards in your computer use this interrupt or these DMA channels.

Conflicts

One of the many advantages that PCI offers over ISA is that the whole issue of address and interrupt assignments is user transparent and under BIOS control. As a result, users typically do not have to be concerned about jumpers or switches when installing a PCI card. Nothing more should be required than to plug in the card, make the connections, and operate the system. As it turns out, however, in certain situations conflicts may nevertheless occur and user intervention will be required to resolve them.

Typical PCI motherboards have both ISA and PCI slots and will have both PCI and ISA cards installed. In the case of the ISA cards, the I/O address and Interrupt assignments will have been made by the user and the BIOS will not know which addresses and interrupts have been user assigned. When a PCI card is installed, the BIOS checks for available addresses and interrupt levels and automatically assigns them so that there are no *PCI* address or interrupt conflicts. However, because the BIOS doesn't know about the user-assigned ISA I/O address and interrupt level assignments, it is possible that a PCI card will be assigned an address or interrupt that is already assigned to an ISA card. If this happens, improper operation will result. Specifically, the problems could range from erratic operation under specific conditions to complete system failure. If such a conflict occurs, because the user has no control over the PCI address and interrupt assignments, there will be no recourse but to examine the ISA assignments and change them to values that do not conflict. Most (but by no means all) ISA cards make provision for selecting alternative I/O addresses and interrupt levels so that conflicts can be resolved. Software is available to help identify specific conflicts.

The following example may serve to illustrate the problem. Suppose you had a system with an ISA network card, a PCI video card and an ISA sound card. Further suppose that you were then going to install a PCI Serial Buffer card. Before installing the PCI Serial card, the I/O address and interrupt assignments for the installed cards might be as shown in Table 9.

Slot Type	Status	I/O Address	Interrupt
1 (ISA)	ISA Network Card	200-210	11
2 (PCI)	PCI Video Card	FF00-FFFF	15
3 (ISA)	ISA Sound Card	300-304	9
4 (PCI)	Empty	N/A	N/A

*Table 9. I/O Address & Interrupt Assignments
before Installing Serial Card*

As shown, there are no conflicts, allowing the three peripheral cards to operate properly. If the PCI Serial card were then installed, the BIOS would interrogate the PCI cards and may reassign them new address and interrupt values as follows.

Slot Type	Status	I/O Address(s)	Interrupt
1 (ISA)	ISA Network Card	200-210	11
2 (PCI)	PCI Video Card	FE00-FEFF	11
3 (ISA)	ISA Sound Card	300-304	9
4 (PCI)	Princeton Instruments (RSPI) PCI Serial Card	FF80-FFFF	15

*Table 10. I/O Address & Interrupt Assignments
after Installing Serial Card*

As indicated, there is now an interrupt conflict between the ISA Network Card and the PCI Video card (both cards have been assigned Interrupt 11), causing the computer to no longer function normally. This doesn't mean that the PCI Serial card is defective because the computer stops functioning properly when the Serial card is installed. What it does mean is that there is an interrupt conflict that can be resolved by changing the interrupt level on the conflicting Network card in this example. It is up to the user to consult the documentation for any ISA cards to determine how to make the necessary change.

Note: Changing the order of the PCI cards, that is, plugging them into different slots, could change the address and interrupt assignments and possibly resolve the conflict. However, this would be a trial and error process with no guarantee of success.

Diagnosics Software

Many diagnostics programs, both shareware and commercial, are available to help resolve conflicts. Most often, all that's required is a program that will read and report the address and interrupt assignments for each PCI device in the computer. One such program available from Princeton Instruments' Customer Support department is called PCICHECK. When the program is run, it reports the address and interrupt assignments for the first PCI device it finds. Each time the spacebar is pressed, it moves on to the next one and reports the address and interrupt assignments for that one as well. In a few moments this information can be obtained for every PCI device in the computer. Note that, even though there are generally only three PCI slots, the number of PCI devices reported may be larger because some PCI devices may be built onto the motherboard. A good strategy for using the program would be to run it before installing the PCI Serial card. Then run it again after installing the card and note any address or interrupt assignments that may have changed. This will allow you to easily focus on the ones that

may be in conflict with address or interrupt assignments on ISA cards. It might be noted that there are many programs, such as the MSD program supplied by Microsoft, that are designed to read and report address and interrupt assignments, including those on ISA cards. Many users have had mixed results at best using these programs.

Operation

There are no operating considerations that are unique to the PCI Serial card. The card can easily accept data as fast as any Princeton Instruments system now available can send it. The incoming data is temporarily stored in the card's memory, and then transferred to the main computer memory when the card gains access to the bus. The PCI bus arbitration scheme assures that, as long as every PCI card conforms to the PCI guidelines, the on-board memory will never overflow.

Unfortunately, there are some PCI peripheral cards that do *not* fully conform to the PCI guidelines and that take control of the bus for longer periods than the PCI specification allows. Certain video cards (particularly those that use the S3 video chip) are notorious in this respect. Usually you will be able to recognize when memory overflow occurs because the displayed video will assume a split-screen appearance and/or the message **Hardware Conflict** will be displayed (in the WinX application). At the same time, the LED on the upper edge of the PCI Serial card will light.

Users are thus advised not to take any actions that would worsen the possibility of memory overflow occurring when taking data. In that regard, avoid multitasking while taking data. Specific operations to avoid include multitasking (pressing ALT TAB or ALT ESC to start another program), or running a screensaver program.

Excessive Readout Noise

Excessive readout noise with the intensifier off indicates possible moisture accumulation in the CCD. This should be corrected promptly or permanent damage not covered by the Warranty could occur.

Normal camera noise is a function of the gain setting and temperature as well as CCD type, but is typically in the range of 1 ADU rms (6 ADU pk-pk). This is on top of offset that typically is about 40 counts. Moisture accumulation produces a coarser noise with many spikes ≥ 30 ADU. If these types of spikes occur, especially after the camera has been in use for an extended period, turn off the system immediately. Have the unit serviced by Princeton Instruments or an authorized service facility of Princeton Instruments.

No CCD Named in the Hardware Wizard: CCD dialog (Versions 2.5.19.0 and earlier)

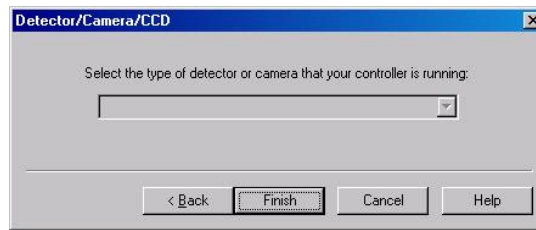


Figure 64. Hardware Wizard: Detector/Camera/CCD dialog box

If you have installed a USB 2.0 Interface Module in your ST-133, a blank field may be displayed in the Detector/Camera/CCD dialog box (Figure 64) if the ST-133 controller was made before January 2001. Earlier versions of the ST-133 did not contain non-volatile RAM (NVRAM), which is programmed with information about the controller and the camera. PVCAM, the program under which the Princeton Instruments USB works, retrieves the information stored in NVRAM so it can enter specific camera characteristics into the WinX application.

Check the serial label on underside of your controller. If the first five characters are D1200 (December 2000) or earlier (J0797 or July 1997, for example), contact Customer Support to find out about an NVRAM controller upgrade.

No Images

See "*Overexposed or Smeared Images*", page 103.

Overexposed or Smeared Images

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

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

Program Error message



Figure 65. Program Error dialog box

This dialog may appear if you have tried to acquire a test image, acquire data, or run in focusing mode and the DMA buffer size is too small. A large array (for example, a 2048x2048 array), requires a larger setting than that for a smaller array (for example, a 512x512 array).

To correct the problem:

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

Removing/Installing a Module

The ST-133 Controller has three plug-in slots. The Analog/Control module (leftmost slot when the controller is viewed from the rear) and the Interface Control module (either a TAXI or a USB 2.0 compatible module in the middle slot) are always provided. For VersArray systems, the third slot is covered with a blank panel.

If a module is ever removed for any reason, internal settings should *not* be disturbed. Changing a setting could radically alter the controller's performance. Restoring normal operation again without proper equipment and guidance would be very difficult, and it might be necessary to return the unit to the factory for recalibration.

WARNING!

1. Always turn the Controller OFF before removing or installing a module. If a module is removed or installed when the controller is powered, permanent equipment damage could occur which would not be covered by the warranty.
2. Before handling any boards, take precautions to prevent electrostatic discharge (ESD). The modules are susceptible to ESD damage. Damage caused by improper handling is not covered by the Warranty.

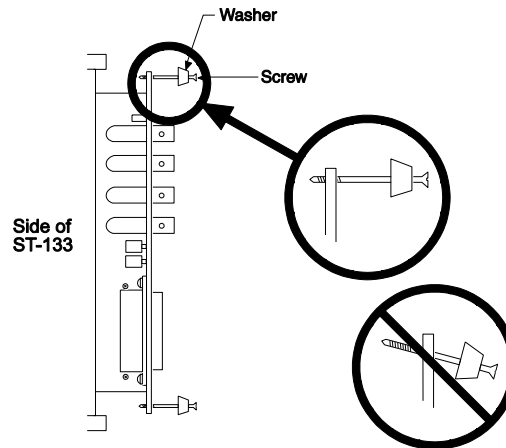


Figure 66. Module Installation

To Remove a Module:

1. Verify that the Controller has been turned OFF.
2. Rotate the two locking screws (one at the top of the module and one at the bottom) counterclockwise until they release from the chassis.
3. Then, grasp the module and pull it straight out.
4. Set the module aside in a safe place. If you are replacing it with another module, as in the case of exchanging a TAXI module with a USB 2.0 module, you may be able to use the packaging from the new module to store the module being replaced. This packaging is usually an antistatic bag that will protect the module components from electrostatic discharge.

To Install a Module:

Installing a module is a bit more complex because you first have to be sure the locking screws are aligned correctly. The following procedure is suggested.

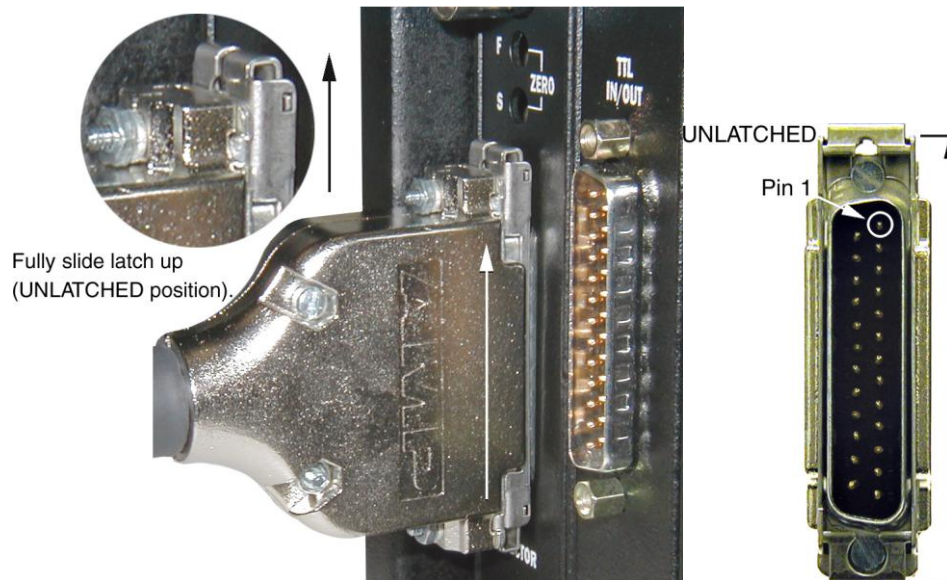
1. Verify that the Controller has been turned OFF.
2. Remove the replacement module from its antistatic packaging. This packaging is designed to protect the module components from electrostatic discharge.
3. Rotate the two locking screws counterclockwise until the threads on the screws engage those of the module panel. *See Figure 66.* By doing this, the screws will be perfectly perpendicular to the module panel and will align perfectly when the module is inserted.
4. Insert the module so that the top and bottom edges of the board are riding in the proper guides.
5. Gently but firmly push the module in until the 64-pin DIN connector at the back of the module mates with the corresponding connector on the backplane, leaving the module panel resting against the controller back panel.
6. Rotate the two locking screws clockwise. As the screws are rotated, they will first disengage from the module panel threads, and then begin to engage those of the bracket behind the controller panel.

WARNING! Tighten the screws to where they are just snug. Do *not* tighten them any further because you could easily bend the mating bracket.

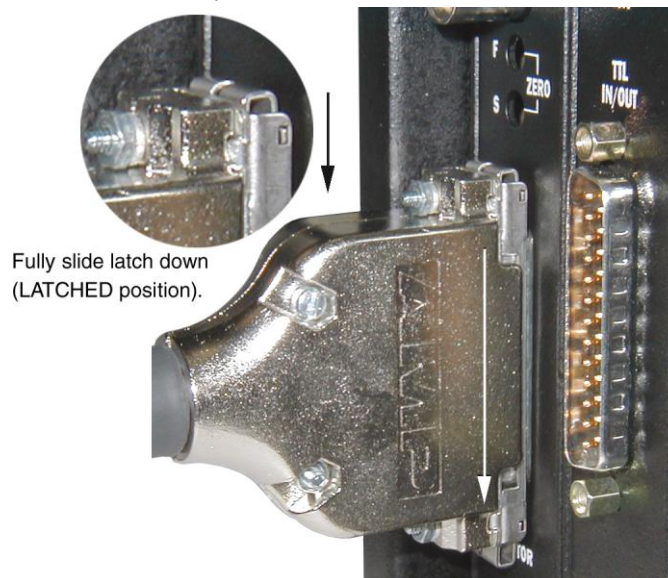
Securing the Detector-Controller Cable Slide Latch

Some Princeton Instruments Detector-Controller cables use a slide latch to secure the Detector-Controller cable to the DETECTOR connector on the back of the ST-133. Incorrectly plugging this cable into the connector and improperly securing the slide latch may prevent communication with the VersArray (the camera may appear to stop working).

1. Before trying to plug in the cable, slide the latch up (toward Pin 1). Then, plug the cable into the DETECTOR connector on the ST-133.



2. Slide the latch down. You may hear a click when the latch locks.



3. Verify that the connector is fully secured.

If you are having trouble sliding the latch, slightly pull the connector out and then slide the latch into its locked position.

Serial violations have occurred. Check interface cable.

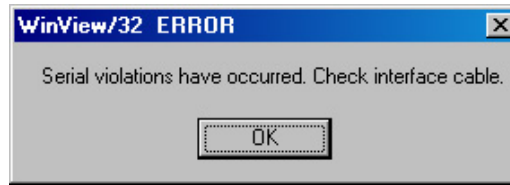


Figure 67. Serial Violations Have Occurred dialog box

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

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

To correct the problem:

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

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

Shutter Failure

See "*Overexposed or Smearred Images*", page 103.

Vignetting: LN-cooled Cameras

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

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

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Specifications

Window

SI-UV fused-silica quartz

CCD Arrays

EEV (Marconi) CCD77-00: 512x512B/F, MPP, 24 x 24 μm pixels, TE/LN, Standard or XP

E2V (Marconi) CCD47-10: 1024x1024B/F, MPP, 13x13 μm , LN, Standard or XP

EEV (Marconi) CCD36-40: 1340x1300B/F, MPP, 20 x 20 μm pixels, TE/LN

EEV (Marconi) CCD42-40: 2048x2048B/F, MPP, 13.5 x 13.5 μm pixels, TE/LN

Note: The arrays listed are those that were available at the time that the manual was written. Contact Princeton Instruments for an updated list of arrays supported by the VersArray.

Mounts

C-mount (standard threaded video mount)

F-mount (standard Nikon® bayonet mount)

Focal Distance

LN:

Front of Shutter to Focal Plane: 0.894"

TE:

C-mount, Front Surface to Focal Plane: .720"

F-mount, Front Surface to Focal Plane: 1.849"

Fiberoptic, Front Surface to Focal Plane: 1.969"

Note: The shutter has a 3.88" bolt circle.

Shutter

LN/TE: 1.59 in (40 mm) aperture, 28 msec open time, 28 msec close time

Camera Head

Connector: Male, D-subminiature 25-pin power/signal connector

Deepest Operating Temperature:

VersArray System	Cooling Type	Typical
512F/512B	TE air	-45°C
	TE chilled liquid	-60°C
	LN	-120°C
1K/1KB	LN	-120°C
1300F/1300B	TE air	-40°C
	TE chilled liquid	-55°C
	LN	-110°C
2048F/ 2048B	TE air	-40°C
	TE chilled liquid	-55°C
	LN	-110°C
XP 512F/512B	TE air with ambient air at +20°C	-70°C
XP 1K/1KB	TE air with ambient air at +20°C	-70°C

Table 11. Typical Deepest Operating Temperature

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

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

LN-Cooled camera head dimensions:

6.25 in (15.56 cm) width;

9.24 in (23.47 cm) length;

14.56 in (36.98 cm) height;

9 lb (4.2 kg) weight, with shutter, when empty

TE-Cooled camera head dimensions:

C-Mount	F-Mount
4.63 in (11.76 cm) width;	4.63 in (11.76 cm) width;
7.05 in (17.91 cm) length;	8.18 in (20.78 cm) length;
4.63 in (11.76 cm) width;	4.63 in (11.76 cm) width;
7 lb (3.2 kg) weight	7 lb (3.2 kg) weight

Controller

Dimensions: See Appendix B

Controller Weight:

ST-133A: 13 lb (5.9 kg)

ST-133B: 12.5 lb (5.7 kg)

Connectors:

VIDEO: 1 V pk-pk from 75 Ω , BNC connector. Either RS-170 (EIA) or CCIR standard video as specified when system was ordered. Requires connection via 75 Ω cable that must be terminated into 75 Ω .

EXT SYNC: TTL input (BNC) to allow data acquisition to be synchronized with external events. Sense can be positive or negative going as set in software. Trigger Modes and Fast Mode vs. Safe Mode are discussed in Chapter 6.

SCAN: TTL output (BNC) for monitoring detector status. *Logic output is software-selectable as either NOT SCAN or SHUTTER.* When the logic output is NOT SCAN, it is at a TTL low when CCD is being read; otherwise high. When the logic output is SHUTTER, the output precisely brackets shutter-open time (exclusive of shutter compensation) and can be used to control an external shutter or to inhibit a pulser or timing generator. Default selection is SHUTTER.

READY: TTL output (BNC); marks start of *first* exposure. When run is initiated, remains high until completion of cleaning cycles preceding *first* exposure, then goes low and remains low for duration of run.

Detector Interface: female, D-subminiature 25-pin connector for communication and data transfer between the controller and the detector. Provides power to detector.

TTL In/Out: 8 TTL Inputs and 8 TTL Outputs are provided for control via the TTL connector. Refer to "*TTL Control*", page 80, for more information.

TTL Input: external sync

TTL Output: (ready) frame start; (scan) shutter/readout status

TTL Requirements: Rise time \leq 40 nsec, Duration \geq 100 nsec.

AUX BNC connector: Not currently activate. Reserved for future use

SERIAL COM: Data link to computer via proprietary cable connected to this 9-pin "D" connector. Cable lengths to 165 feet (50 m) available. An optional fiber optic link is available to extend the distance to ~3300 feet (1 km).

USB 2.0: Data link to computer via USB cable inserted at this connector. Cable length of 5 meters is standard. Other lengths may be available. Contact Customer Service for more information.

A/D Converters:

Standard: 16-bit, 100 kHz readout rate only. Multiple digitizers are standard with the ST-133 2 MHz controller.

Optional: Dual digitizers with either 100 kHz/1 MHz or 50 kHz/1 MHz readout rates. Software-selectable. Low-speed operation gives better noise performance; high-speed operation allows faster data acquisition.

Power Input: Nominally 100, 120, 220 or 240 VAC. Refer to the Fuse/Voltage label on the back of the controller for details. Required DC voltages are generated in the controller. Power to detector is supplied via controller cable.

Power Consumption: Refer to the back of the controller.

Options

A partial listing of options includes: Internal Shutters, C-mount Adapters, F-mount Adapters, and Spectroscopic Mount Adapters. Contact the factory for more information regarding options available for your system.

Appendix B

Outline Drawings

Note: Dimensions are in inches.

VersArray TE Camera: Air- and Liquid-Assist

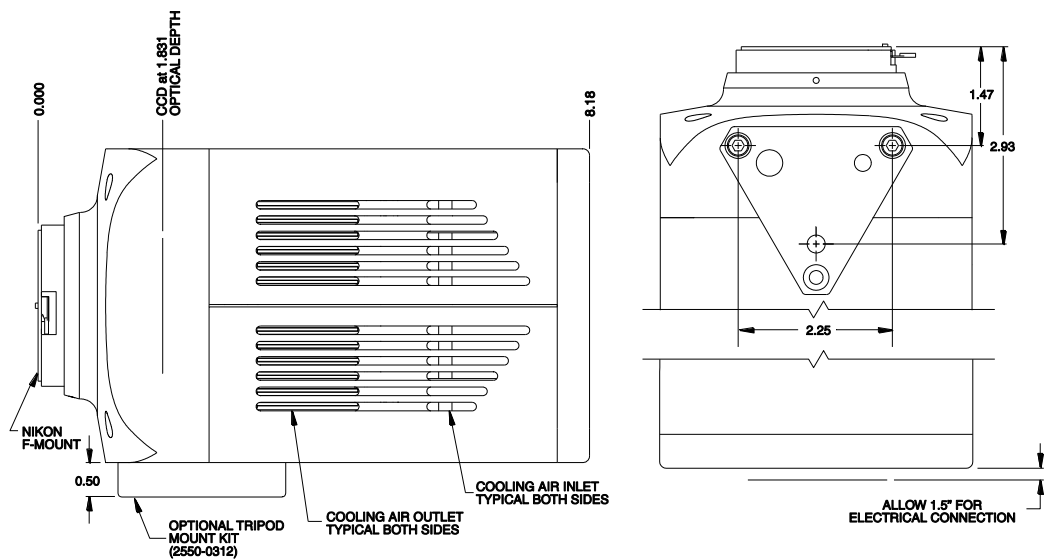


Figure 68. TE F-Mount: Side and Bottom Views

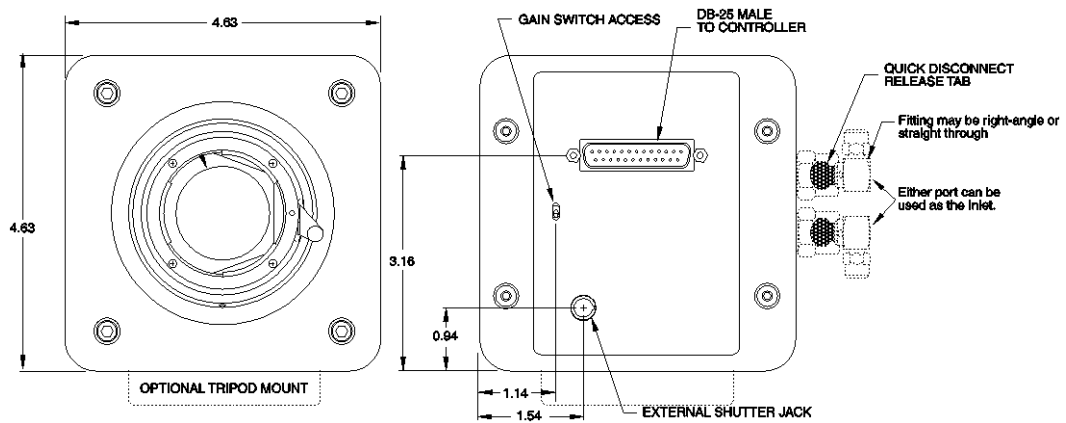


Figure 69. TE F-Mount: Front and Back Views

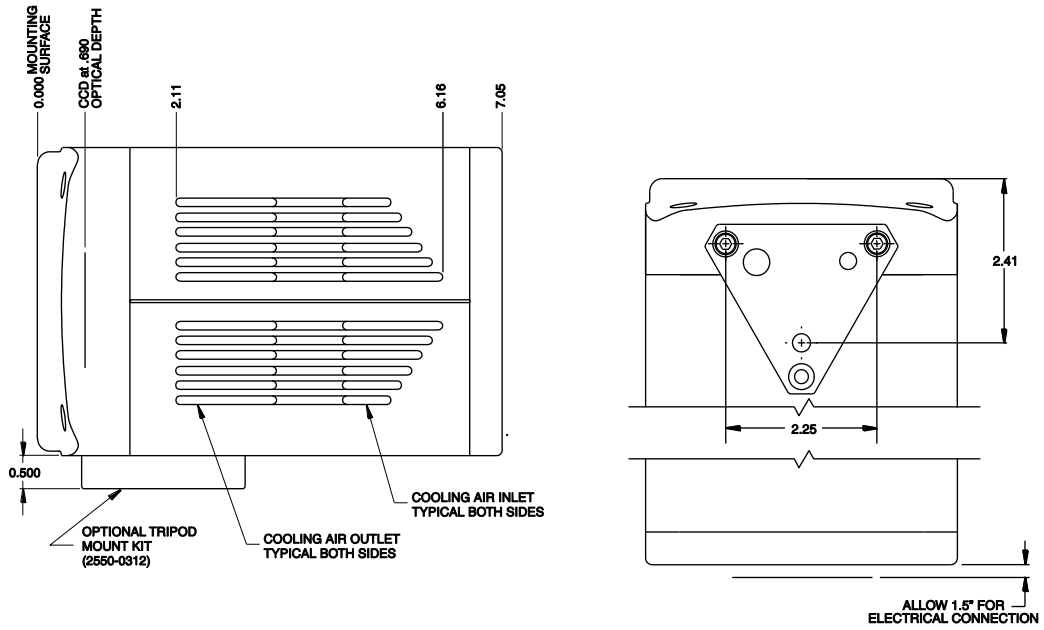


Figure 70. TE C-Mount: Side and Bottom Views

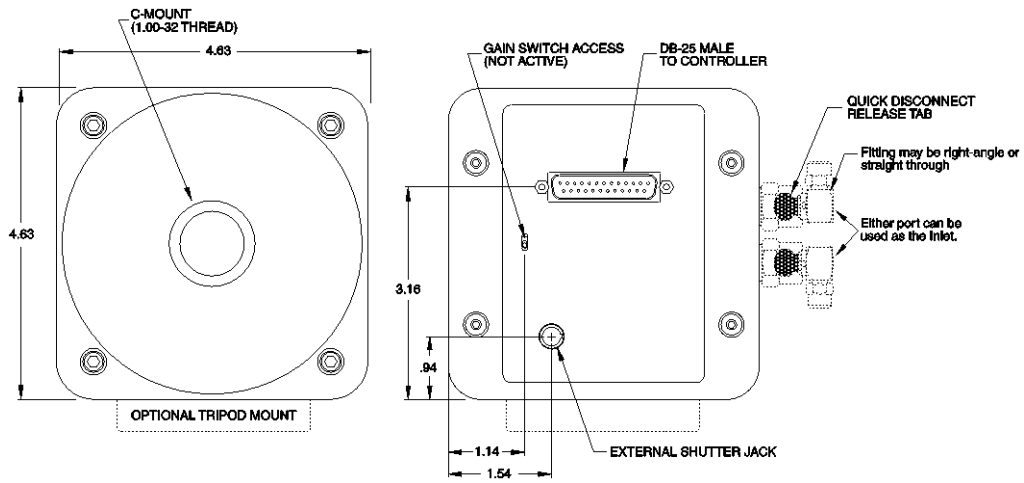


Figure 71. TE C-Mount: Front and Back Views

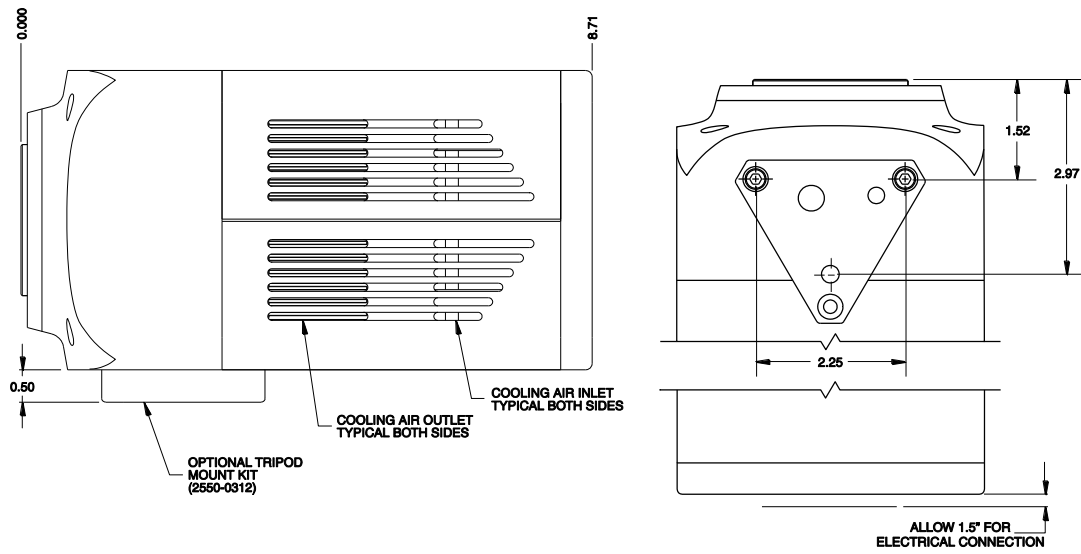


Figure 72. Fiber-Optic Coupled: Side and Bottom Views

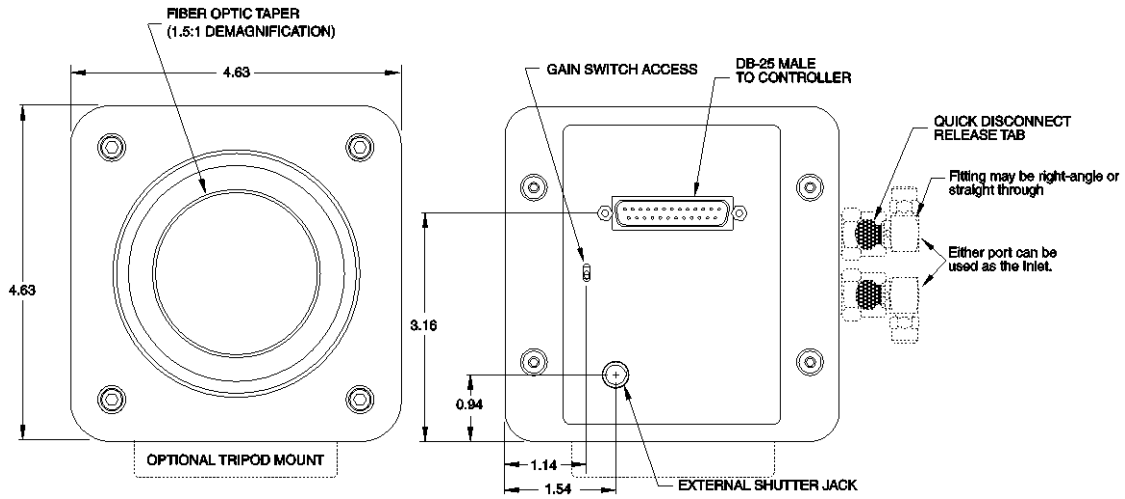


Figure 73. Fiber-Optic Coupled: Front and Back Views

VersArray TE Camera: Liquid-Cooled

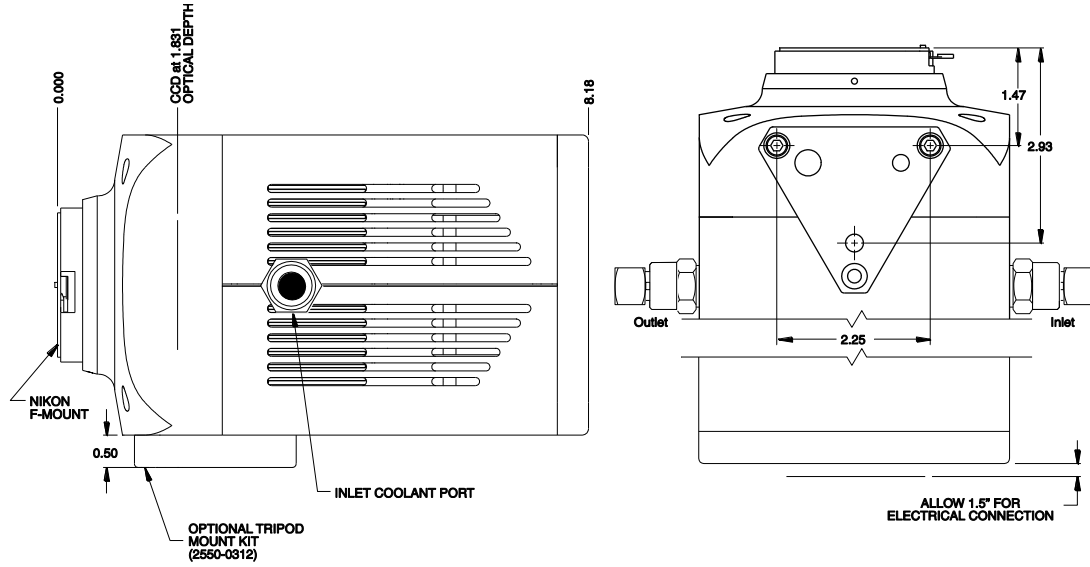


Figure 74. TE F-Mount: Side and Bottom Views

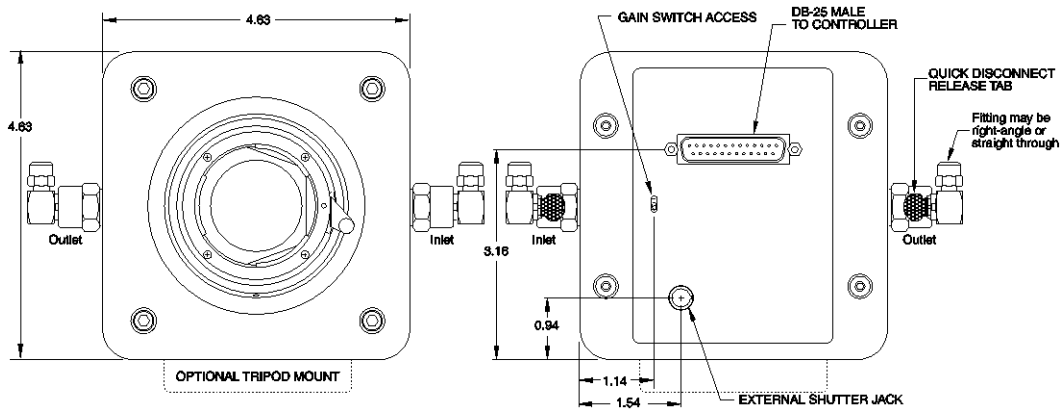


Figure 75. TE F-Mount: Front and Back Views

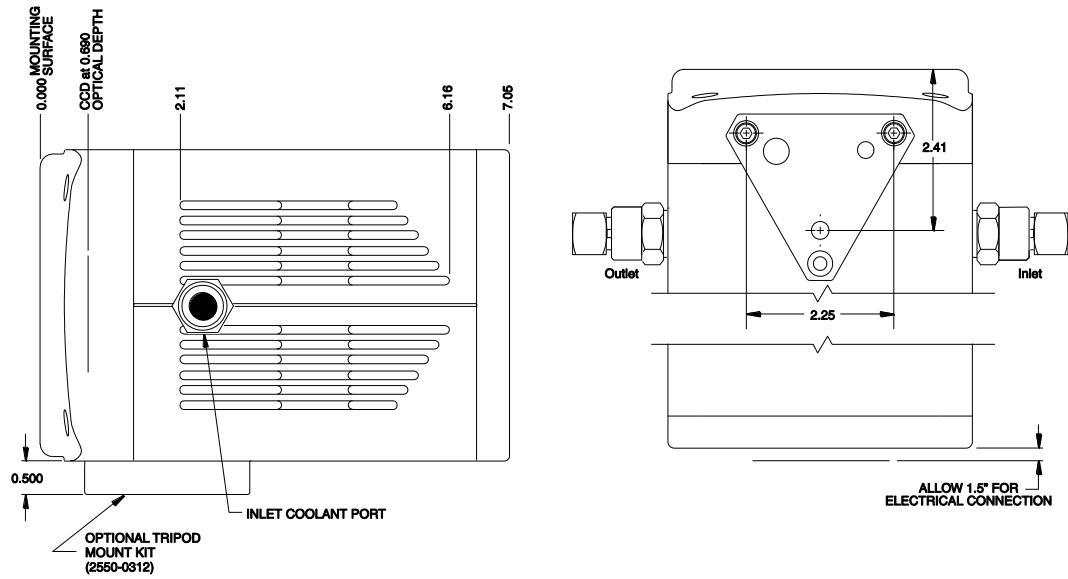


Figure 76. TE C-Mount: Side and Bottom Views

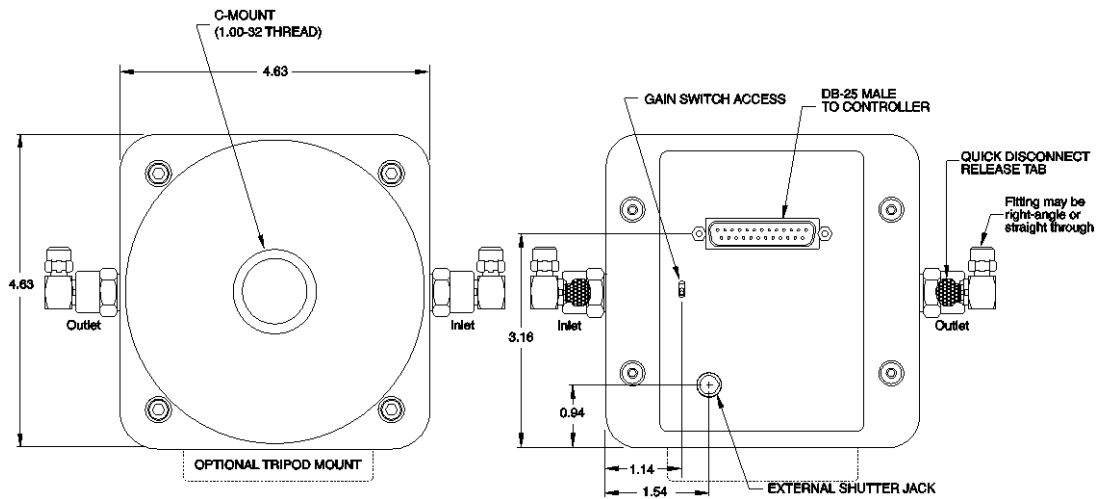


Figure 77. TE C-Mount: Front and Back Views

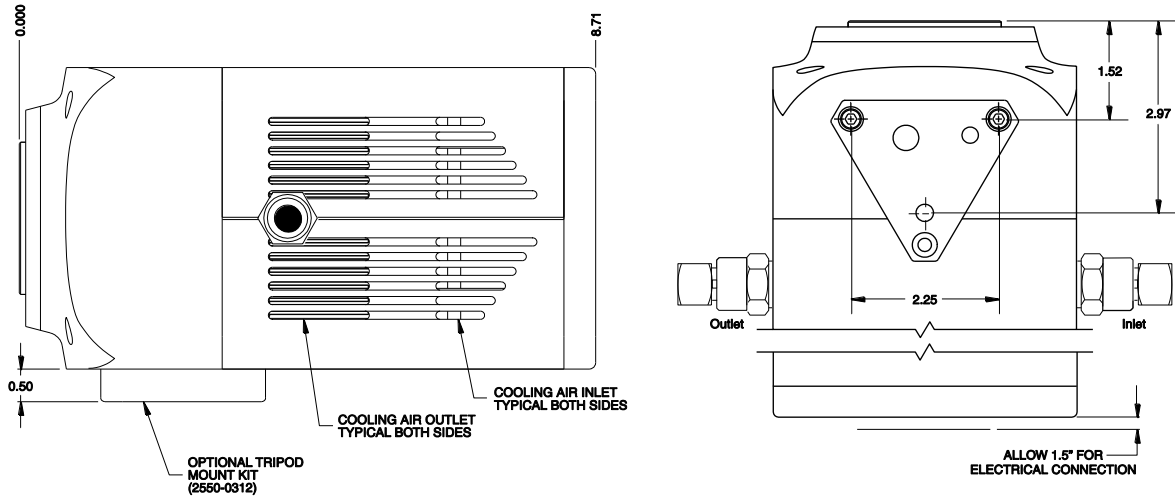


Figure 78. Fiber-Optic Coupled: Side and Bottom Views

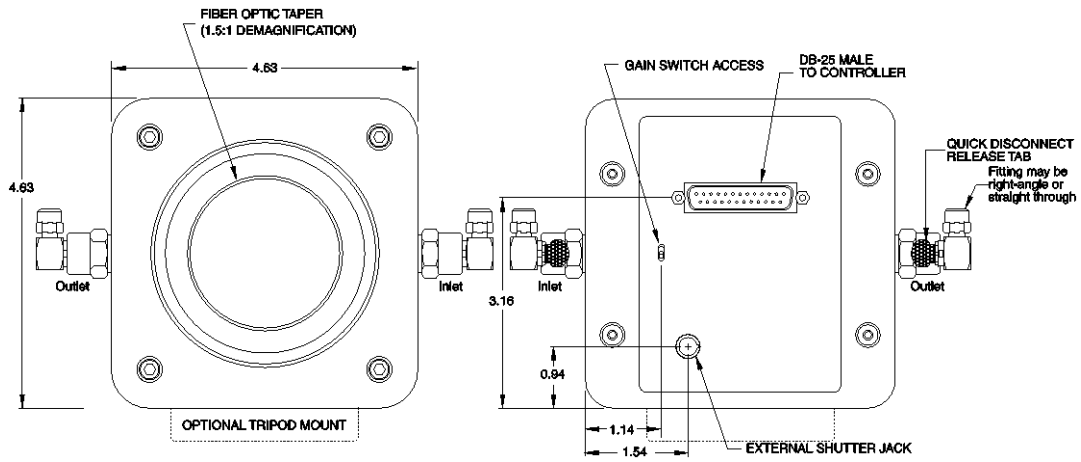


Figure 79. Fiber-Optic Coupled: Front and Back Views

VersArray LN-Cooled Camera

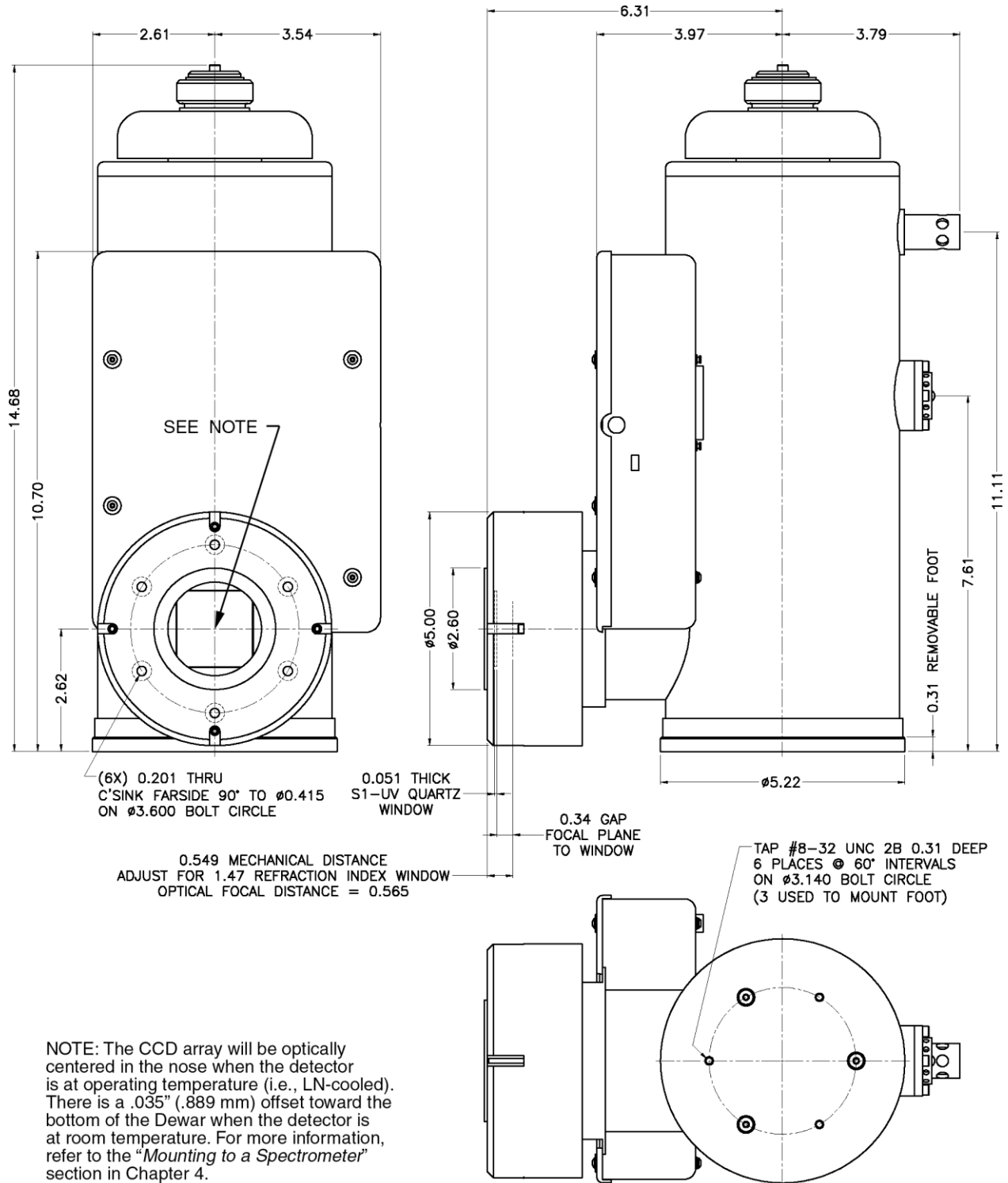


Figure 80. Side-Looking Dewar (Without Shutter): New Design

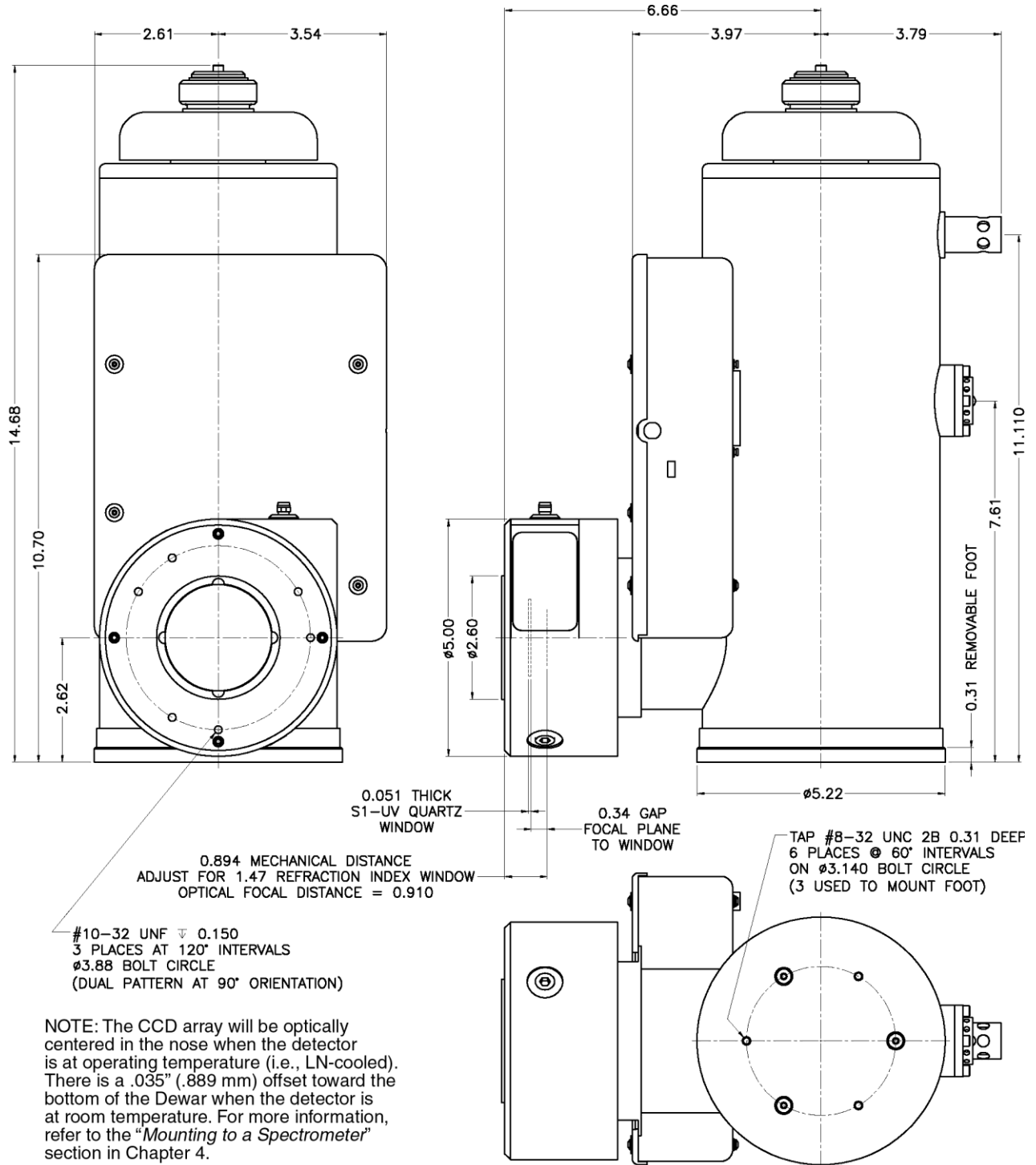


Figure 81. Side-Looking Dewar (With Shutter): New Design

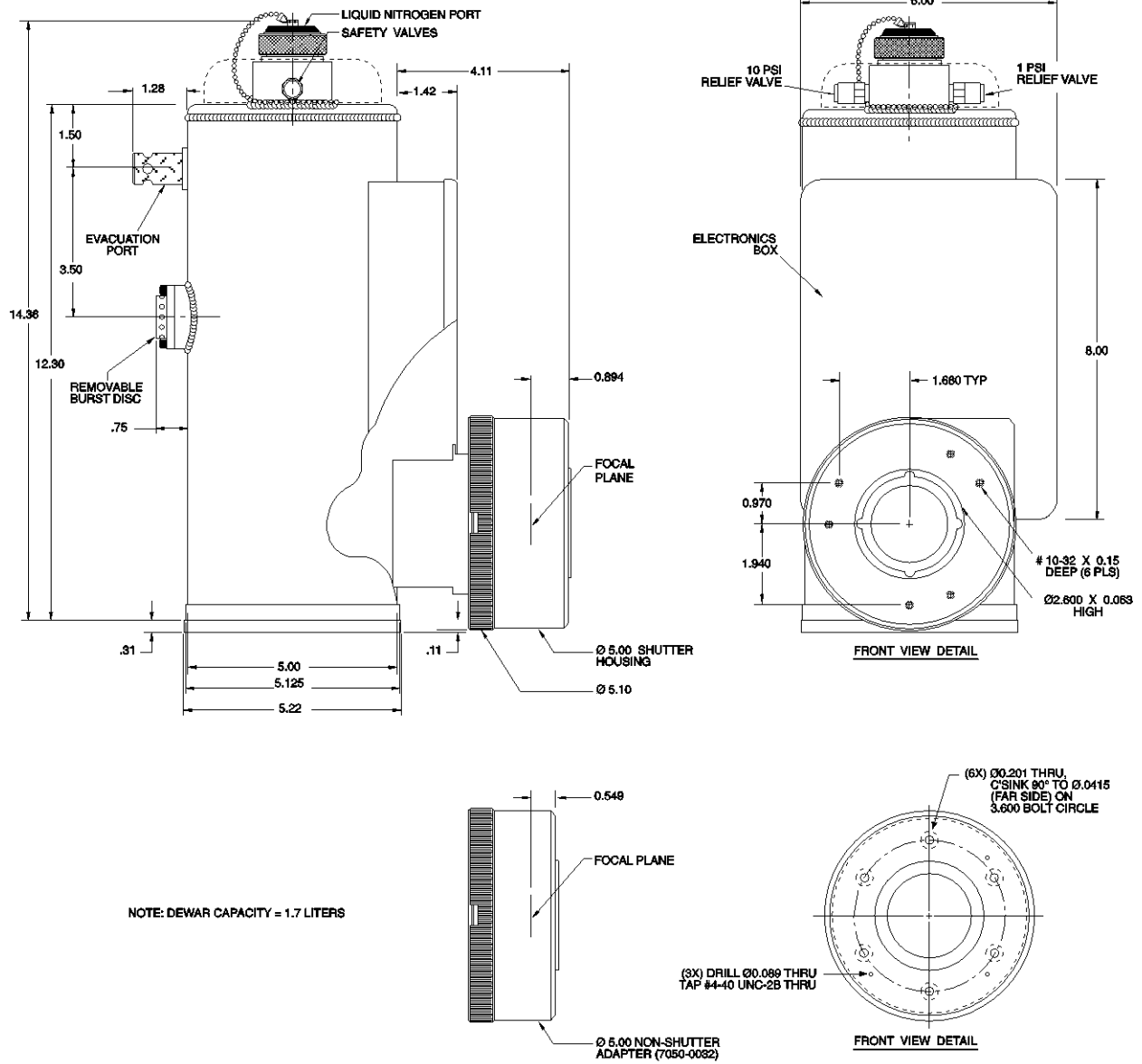


Figure 82. Side-Looking Dewar: Old Design

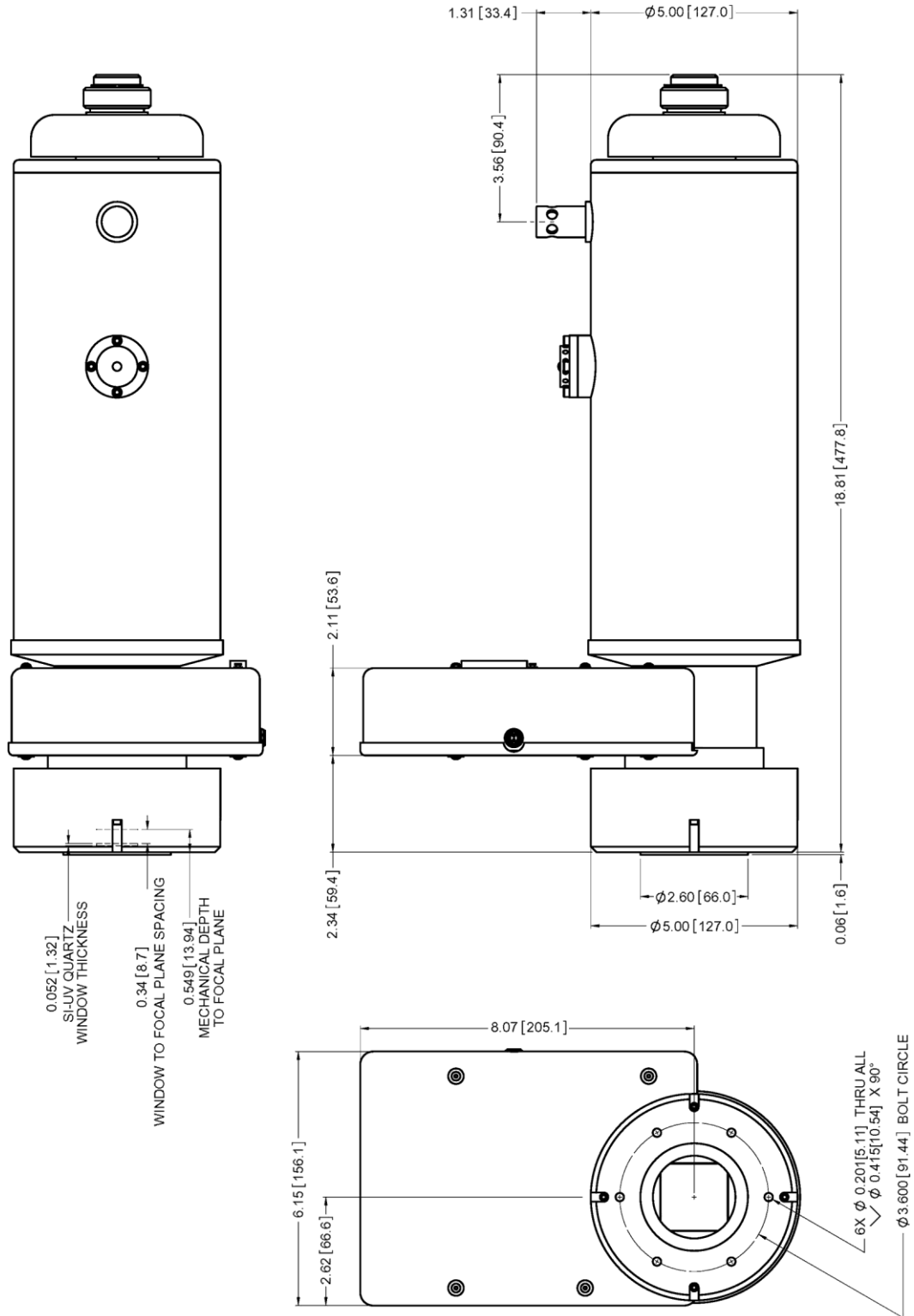


Figure 83. Down-Looking Dewar (Without Shutter): New Design

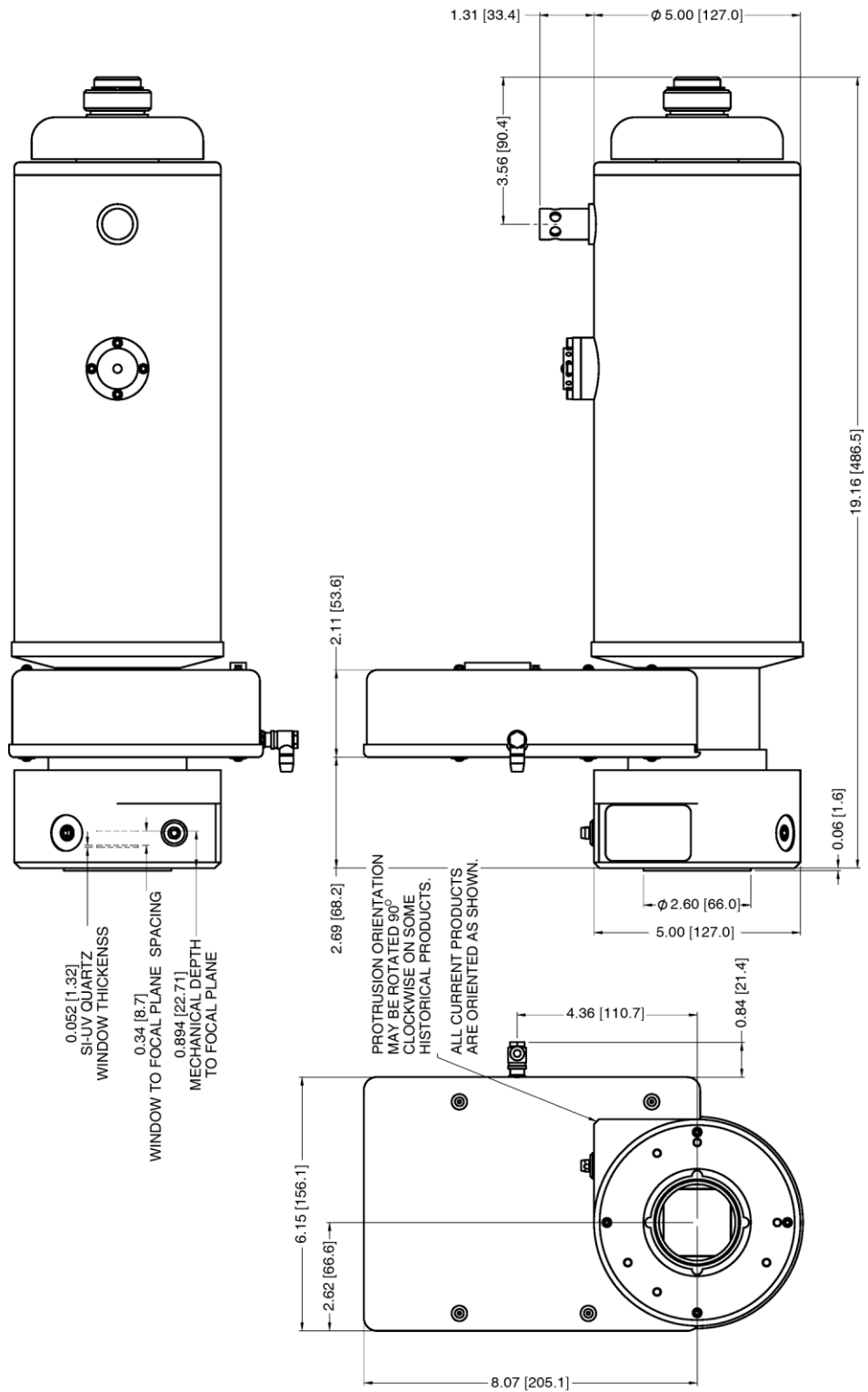


Figure 84. Down-Looking Dewar (With Shutter): New Design

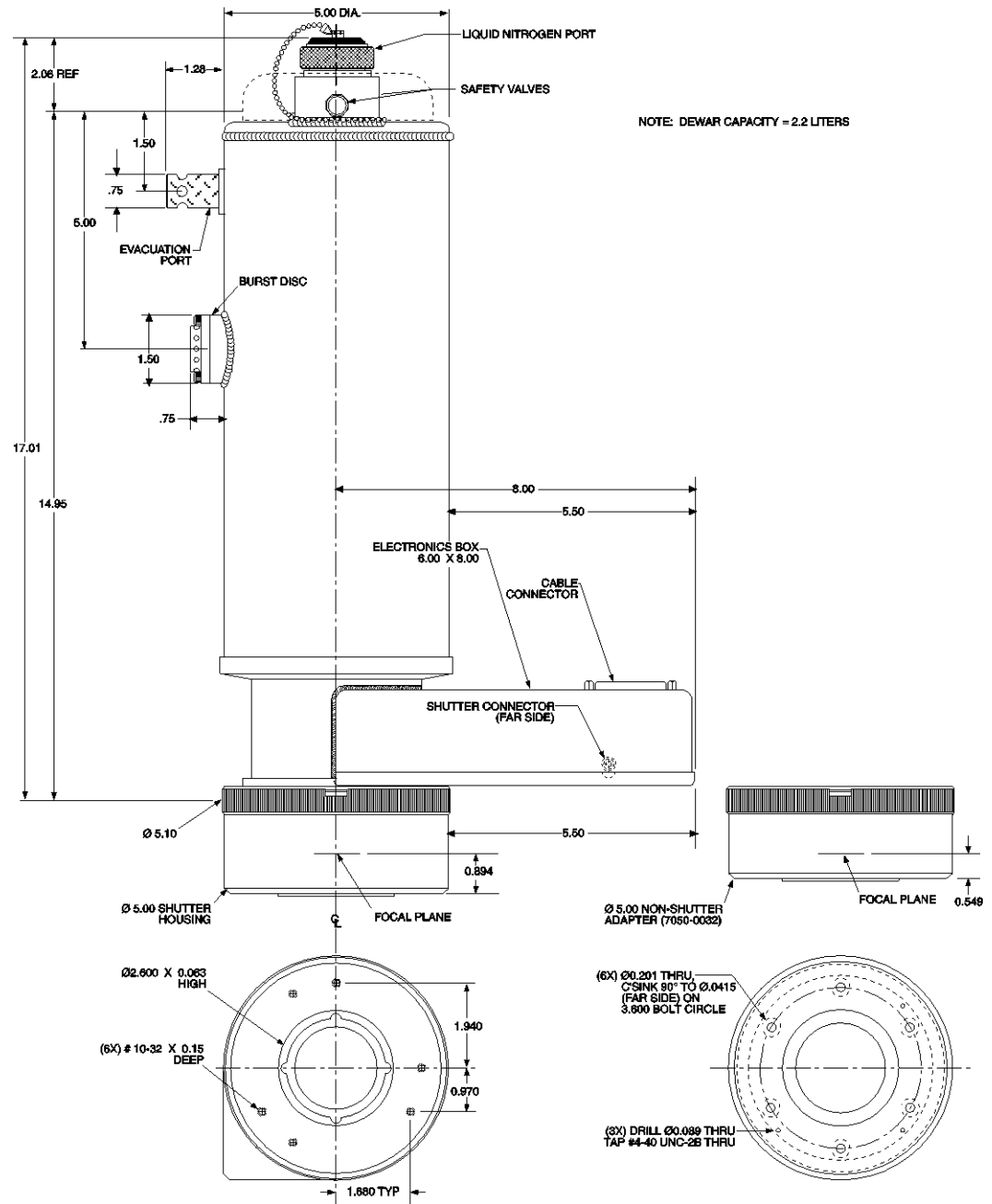


Figure 85. Down-Looking Dewar: Old Design

ST-133B Controller

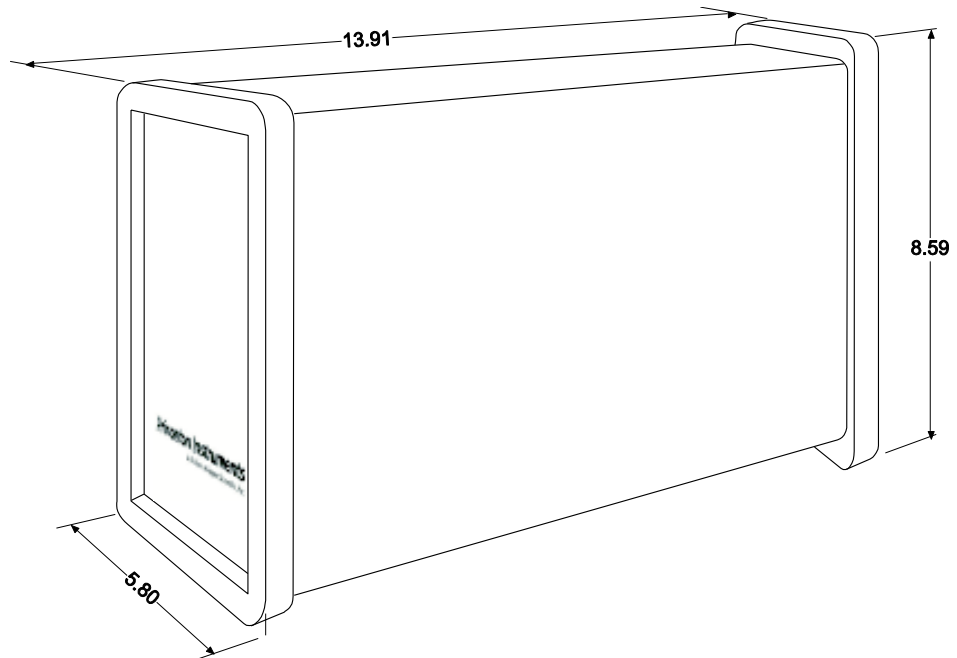


Figure 86. ST-133B Controller Dimensions

ST-133A Controller

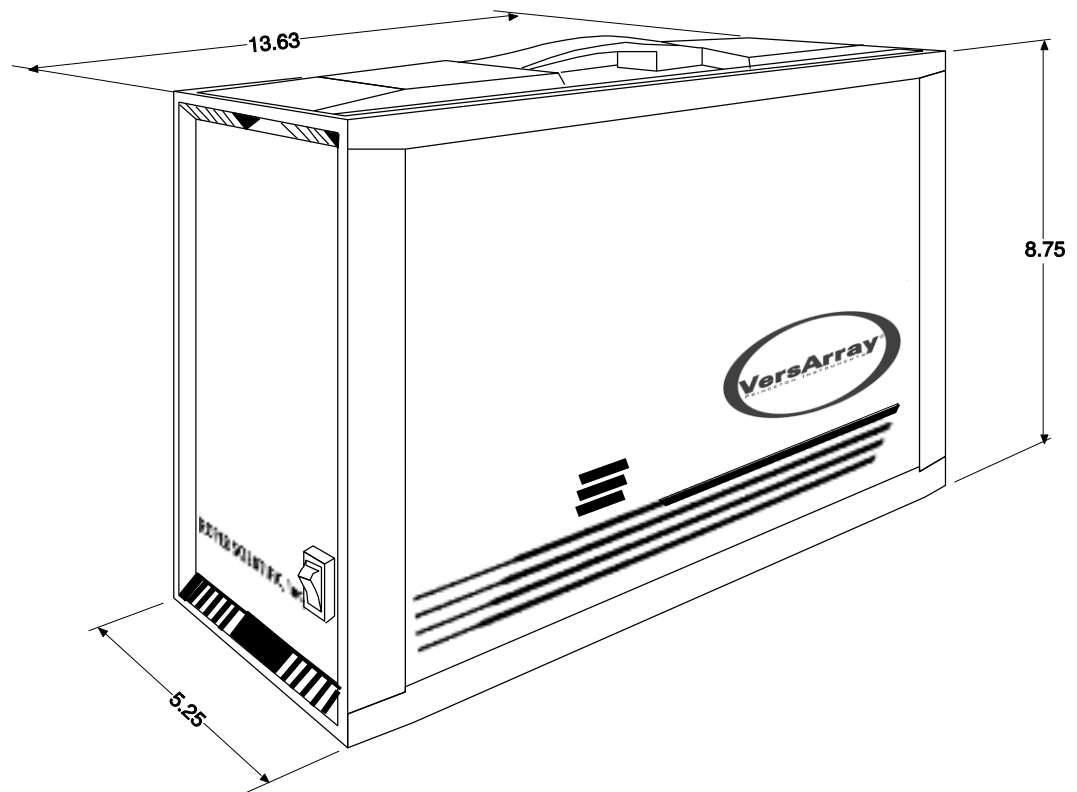


Figure 87. ST-133A Controller Dimensions

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Adapter Focusing Procedures

F-Mount Adapter Focusing Procedure

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

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

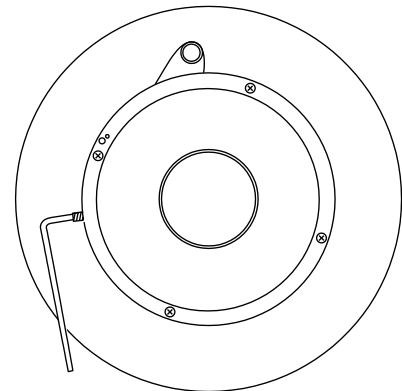


Figure 88. F-mount Adjustment

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

10. Taking care not to disturb the *lens focus*, rotate the *adapter body* for maximum sharpness in the observed image and tighten the setscrews to secure the adapter body's position.

This completes the procedure for adjusting the *F-mount adapter*. It should not be necessary to disturb the adjustment again. In actual measurements with real subjects, the focusing will be done entirely with the *lens focus adjustment*. Microscope adapters follow a similar procedure except, in this case, the front part of the lens mount should not need adjustment. See Chapter 4 for additional information.

Lens Focusing Procedure

Except for the lens mount focus procedure that applies to F-mount lenses as described above, there is no difference between focusing considerations for an F-mount lens and a C-mount lens. Simply use the focusing ring on the lens to produce the sharpest image at full aperture. Then stop the lens down to its sharpest aperture (probably at a mid-range aperture setting) and adjust the Exposure Time for the best possible image as observed at the monitor. In microscopy applications, it will also be necessary to review the discussions in *Mounting a TE-Cooled VersArray Camera to a Microscope*, page 42.

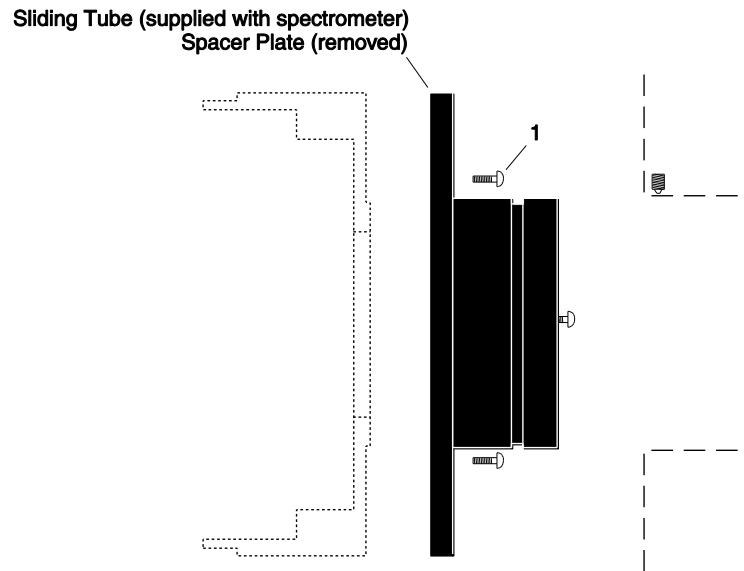
Appendix D

Spectrometer Adapters

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

Spectrometer	Detector Type	Adapter Kit No.	Page
Acton	LN with shutter, NTE with/without shutter		130
Acton	NTE with C-Mount		131
Chromex 250 IS	LN with shutter, NTE with/without shutter	7050-0089	132
ISA HR 320	LN with shutter, NTE with/without shutter	7050-0002	133
ISA HR 640	LN with shutter, NTE with/without shutter	7050-0014	134
JY TRIAX	NTE without shutter	7384-0072	135
SPEX 270M	LN with shutter, NTE with/without shutter	7050-0042	136
SPEX 500M	LN with shutter, NTE with/without shutter	7050-0018	137
SPEX TripleMate	LN with shutter, NTE with/without shutter	7050-0006	138

Acton (LN with shutter, NTE with or without shutter)



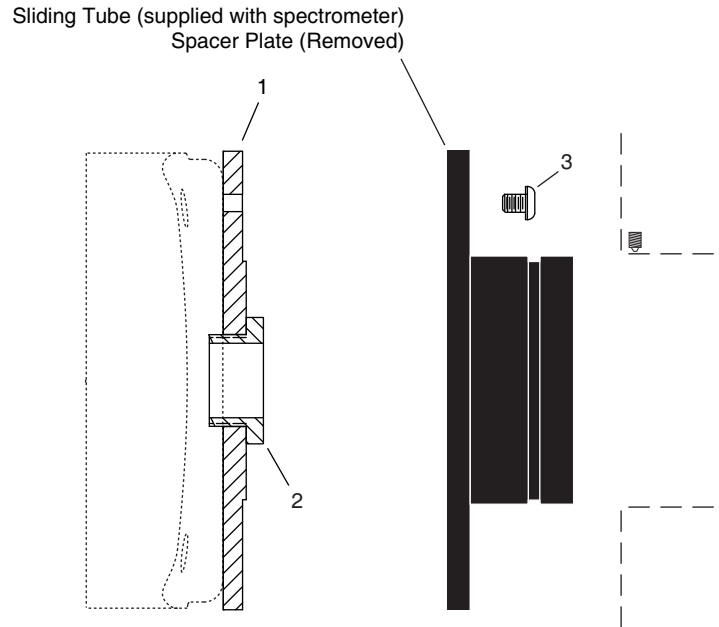
Qty	P/N	Description
1. 3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel

Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrometer.
2. Loosen the setscrews holding the Acton sliding tube in the spectrometer and remove the adapter. If there is a spacer plate installed on the sliding tube, remove it..
3. Mount the sliding tube to the face of the detector drum housing (dashed outline in illustration) with the three (3) 1/4" long button head screws.
4. Gently insert the sliding tube into the spectrometer and fasten with the setscrews.

Note: Spectrometer parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting the sliding tube into the spectrometer. Forcing the tube into the spectrometer could permanently damage the tube and the spectrometer opening.

Acton (NTE with C-Mount)



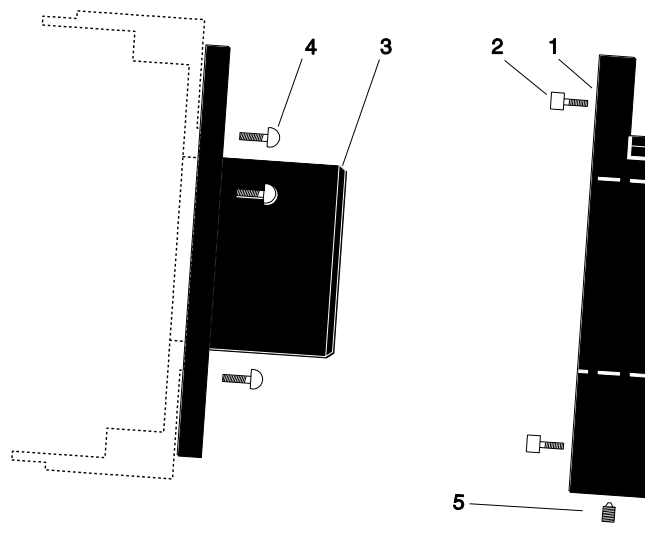
Qty	P/N	Description
1.	1 8401-071-01	Adapter Plate
2.	1 8401-071-02	Threaded C-Mount Adapter
3.	3 2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel

Assembly Instructions

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

Note: Spectrometer parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting the sliding tube into the spectrometer. Forcing the tube into the spectrometer could permanently damage the tube and the spectrometer opening

Chromex 250 IS (LN with shutter, NTE with or without shutter)



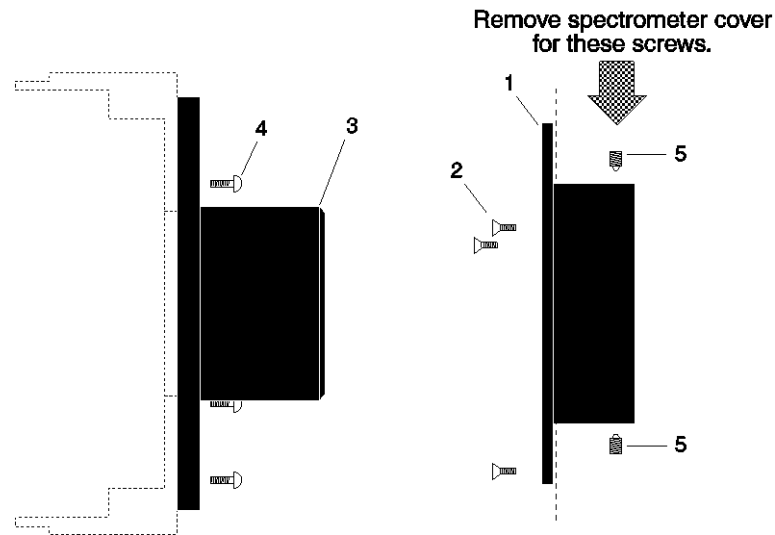
Qty	P/N	Description
1.	1	2517-0901 Plate, Adapter-Female
2.	4	2826-0283 Screw, 10-32 × 3/4, Socket head, Stainless Steel, Hex, Black
3.	1	2518-0107 Adapter-Male, HR320
4.	3	2826-0127 Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	1	2826-0082 Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer (dashed line in illustration) with the socket head screws provided.
2. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrew.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

ISA HR 320 (LN with shutter, NTE with or without shutter)



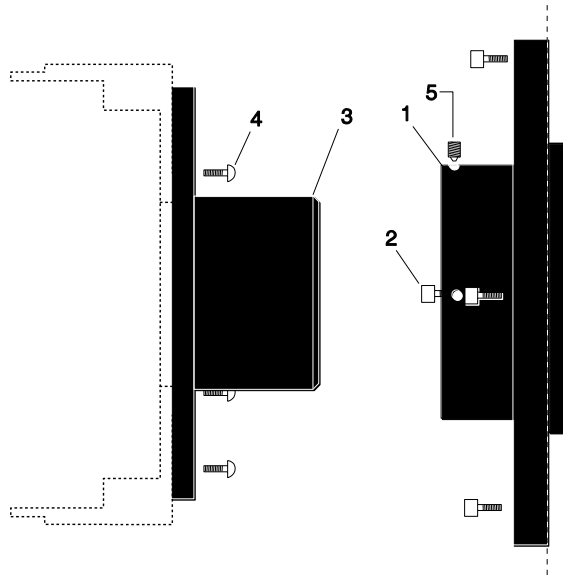
Qty	P/N	Description
1.	1	2518-0106 Adapter-Female, HR320
2.	3	2826-0087 Screw, M5-10, Flat Head, Socket, Stainless Steel
3.	1	2518-0107 Adapter-Male, HR320
4.	3	2826-0127 Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	2	2826-0082 Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Remove the spectrometer cover.
2. Insert part 1 into the spectrometer (dashed line in illustration), fasten with the flathead screws provided, and replace spectrometer cover.
2. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrews.
4. Replace the spectrometer cover.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

ISA HR 640 (LN with shutter, NTE with or without shutter)



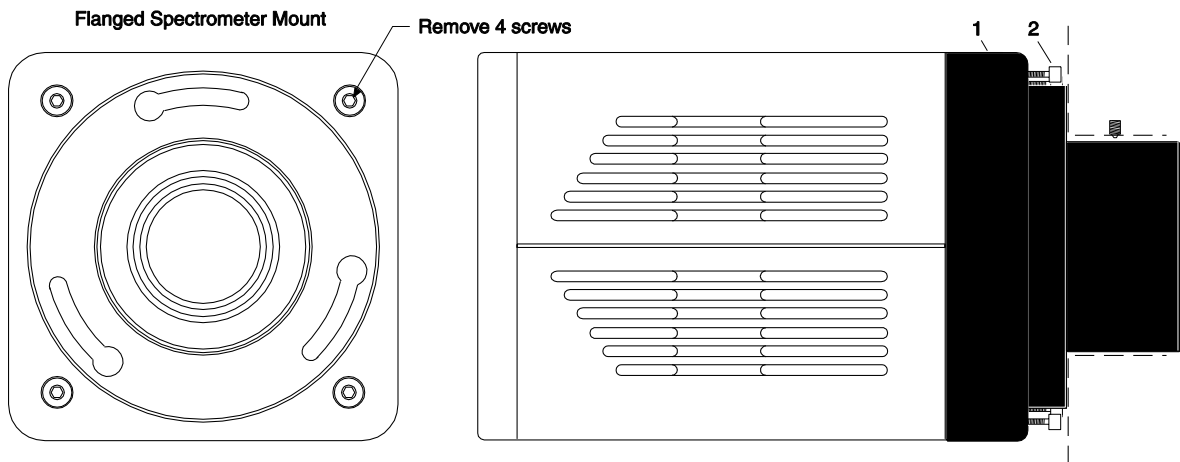
	Qty	P/N	Description
1.	1	2518-0203	Adapter-Female, HR640
2.	4	2826-0144	Screw, M4-.7 × 14, Socket Head Cap, Stainless Steel
3.	1	2518-0107	Adapter-Male, HR320
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	2	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Insert part 1 into the spectrometer (dashed line in illustration) and fasten with the socket head screws provided.
2. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

JY TRIAX family (NTE without shutter)



Qty	P/N	Description
1.	1	2518-1000 Adapter, TRIAX, NTE, 7377, 7376, 7413
2.	4	2826-0191 Screw, 10-32 × 5/8, Socket Head, Stainless Steel, Hex, Black

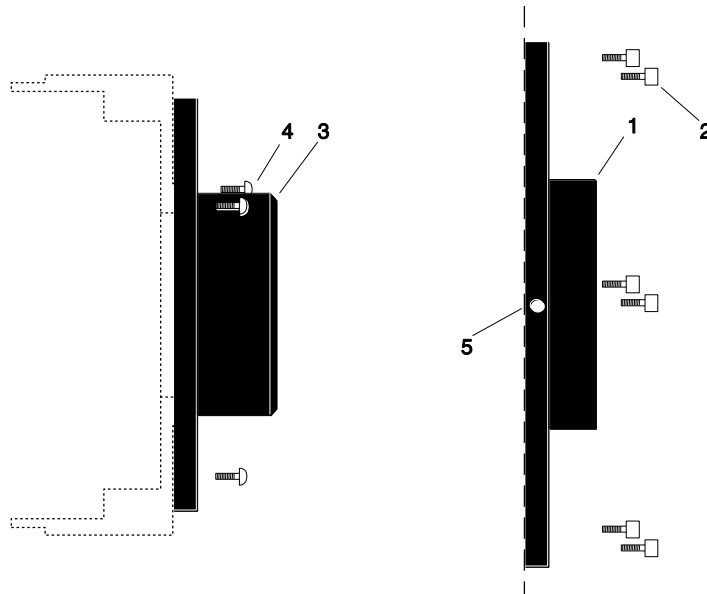
Typically, the adapter is shipped already mounted to the detector. The following procedure is provided in case you have ordered a JY TRIAX adapter for a shutterless NTE camera that you already own.

Assembly Instructions

1. While supporting the flange, remove the four (4) of the socket head screws from the front of the detector (see illustration above) and store these screws.
2. Using the four (4) screws provided with the adapter kit, mount part 1 to the front of the detector.
3. Remove the spectrometer cover.
4. Insert part 1 into the spectrometer and fasten it in place with the spectrometer setscrew.
5. Replace the spectrometer cover.

Note: Adapter parts are machined to provide a tight fit. It may be necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force

SPEX 270M (LN with shutter, NTE with or without shutter)



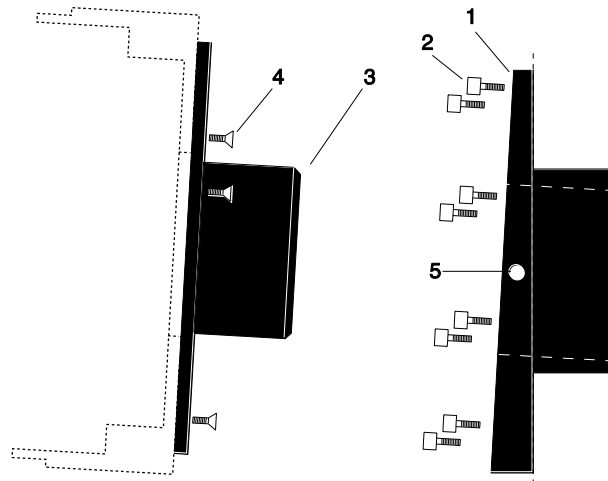
Qty	P/N	Description
1	2518-0691	Female Adapter Plate, 2.400 ID
6	2826-0068	Screw, 6-32 × 3/8, Socket Head, Cap, Stainless Steel
1	2518-0690	Adapter, Focusing, Male, Spec 270
3	2826-0127	Screw, 10-32 × 1/4, Button Head, Hex, Stainless Steel
2	2826-0073	Screw 6-32 × 1/8, Set, Allen Hex, Brass Tip

Assembly Instructions

1. Remove the cover of the spectrometer.
2. Attach part 1 to the inner wall of the spectrometer (dashed line in illustration) with the socket head screws provided.
3. Attach part 3 to the detector with the three (3) 1/4" long button head screws provided.
4. Gently insert part 3 into part 1 and fasten with the setscrews.
5. Replace the spectrometer cover.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

SPEX 500M (LN with shutter, NTE with or without shutter)



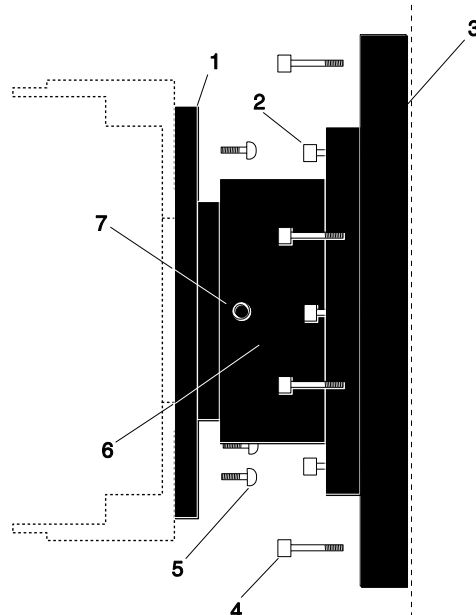
Qty	P/N	Description
1.	1	2517-0214 Adapter-Female, Spex 500m
2.	8	2826-0170 Screw, 1/4-20 × 0.51, Low Socket Head Cap, Black
3.	1	2518-0223 Adapter-Male, Spex 500m
4.	3	2826-0134 Screw, 10-32 × 1/4, Flat Head Slot, Stainless Steel (Prontor)
5.	2	2826-0055 Screw, 8-32 × 14, Set Allen Hex, Nylon

Assembly Instructions

1. Insert part 1 into the spectrometer wall (dashed line in illustration) and fasten with the socket head screws provided.
2. Attach part 3 to the detector with the three (3) 1/4" long flathead screws provided.
3. Gently insert part 3 into part 1 and fasten with the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

SPEX TripleMate (LN with shutter, NTE with or without shutter)



Qty	P/N	Description
1.	1	2518-0184 Adapter-Male, LN/TE, CCD/For Spex TripleMate
2.	4	2826-0128 Screw, 10-32 × 5/8, Socket Head Cap, Stainless Steel,
3.	1	2517-0163 Slit Mount, Spex
4.	4	2826-0129 Screw, 1/4-20 × 3/4, Socket Head Cap, Stainless Steel
5.	3	2826-0127 Screw, 10-32 × 1/4, Button Head, Hex, Stainless Steel (Prontor)
6.	1	2518-0185 Adapter-Female, Flange Spex
7.	2	2826-0082 Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip
	1	2500-0025 O-ring, 2.359x.139, Viton (installed)
	1	2500-0026 O-ring, 2.484x.139, Viton (installed)

Assembly Instructions

1. Mount the whole assembly onto the spectrometer.
2. Loosen setscrews and pull out part 1 far enough to enable access to screws with Allen wrench. Do not pull part 1 past the O-ring (If you do pull out part 1 completely, reinsert before attaching the detector).
3. Attach the detector to part 1 with the three (3) 1/4" button head screws provided.
4. Tighten the setscrews.

Note: Adapter parts are machined to provide a tight fit. It is necessary to rotate the detector back and forth when inserting into the spectrometer adapter. Do not force the two parts of the adapter together, as they can be permanently damaged by excessive force.

Appendix E

USB 2.0 Limitations

The following information covers the currently known limitations associated with operating under the USB 2.0 interface.

- Maximum cable length is 5 meters (16.4 feet)
- 1 MHz is currently the upper digitization rate limit for the ST-133 Controller.
- Large data sets and/or long acquisition times may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (Easy DLLS).
- Some WinView/WinSpec 2.5.X features are not fully supported with USB 2.0. See the table below.

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Demo Port Capability	NO	
DIF	NO	
Kinetics	YES	WinX 2.5.18.1
Reset Camera to NVRAM Defaults	NO	
Temperature Lock Status	YES	WinX 2.5.x doesn't utilize hardware lock status
PTG	YES	
Virtual Chip	NO	
Custom Timing	YES	WinX 2.5.18.1
Custom Chip	YES	WinX 2.5.18.1
Frames per Interrupt	NO	
RS170 (Video Output)	NO	
Online Exposure	NO	
File Information	YES	Not all header info is currently available in WinX 2.5.x through PVCAM
Overlapping ROIs	NO	

Table 12. Features Supported under USB 2.0 (continued on next page)

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Macro Record	YES	Macros recorded for non-PVCAM cameras may have to be re-recorded to function
TTL I/O	NO	

Table 12. Features Supported under USB 2.0

Declarations of Conformity

This section of the VersArray manual contains the declarations of conformity for VersArray systems. VersArray systems encompass LN-cooled, NTE-cooled, and TEA-cooled camera heads and their associated controllers.

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133 CONTROLLER w/LN CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

**IEC 61010-1:2001,
EN 61326:2000, Class A,
(EN 61000-4-2:1995, EN 61000-4-3:1995, EN 61000-4-4:1995,
EN 61000-4-5:1995, EN 61000-4-6:1996, EN 61000-4-11:1994),
EN 61000-3-2:2000, and EN 61000-3-3:2001,**

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC with Amending Directive 93/68/EEC.

Date: August 7, 2002
TRENTON, NJ


(PAUL HEAVENER)
Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133 1MHz HIGH POWER CONTROLLER
w/NTE CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 61010-1:2001,
EN 61326:2000, Class A,
(EN 61000-4-2:1995, EN 61000-4-3:1995, EN 61000-4-4:1995,
EN 61000-4-5:1995, EN 61000-4-6:1996, EN 61000-4-11:1994),
EN 61000-3-2:2000, and EN 61000-3-3:2001,

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC with Amending Directive 93/68/EEC.

Date: August 20, 2002
TRENTON, NJ



(PAUL HEAVENER)
Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133 1MHz HIGH POWER CONTROLLER
w/TEA CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 61010-1:2001,
EN 61326:2000, Class A,
(EN 61000-4-2:1995, EN 61000-4-3:1995, EN 61000-4-4:1995,
EN 61000-4-5:1995, EN 61000-4-6:1996, EN 61000-4-11:1994),
EN 61000-3-2:2000, and EN 61000-3-3:2001,


Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC with Amending Directive 93/68/EEC.

Date: August 20, 2002
TRENTON, NJ



(PAUL HEAVENER)
Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133A 2 MHz PCI CONTROLLER with VERSARRAY XP CAMERA,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

**IEC 1010-1:1990, EN 61010-1:1993/A2:1995,
EN 61326 for Class A, 1998,
(EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5,
EN 61000-4-6, EN 61000-4-11), EN 61000-3-2:2000, and
EN 61000-3-3:1995,**

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC.

Date: July 18, 2003
TRENTON, NJ



(PAUL HEAVENER)
Engineering Manager

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC
(PRINCETON INSTRUMENTS)
3660 QUAKERBRIDGE ROAD
TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133 1 MHz USB 2.0 CONTROLLER with VERSARRAY XP CAMERA,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

**IEC 61010-1:2001,
EN 61326:2000, Class A,
(EN 61000-4-2:1995, EN 61000-4-3:1995, EN 61000-4-4:1995,
EN 61000-4-5:1995, EN 61000-4-6:1996, EN 61000-4-11:1994),
EN 61000-3-2:2000, and EN 61000-3-3:2001,**

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC with Amending Directive 93/68/EEC.

Date: July 21, 2003
TRENTON, NJ



(PAUL HEAVENER)
Engineering Manager

Warranty & Service

Limited Warranty

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

Basic Limited One (1) Year Warranty

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

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

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

XP Vacuum Chamber Limited Lifetime Warranty

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

Sealed Chamber Integrity Limited 12 Month Warranty

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

Vacuum Integrity Limited 12 Month Warranty

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

Image Intensifier Detector Limited One Year Warranty

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

X-Ray Detector Limited One Year Warranty

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

Software Limited Warranty

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

Owner's Manual and Troubleshooting

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

Your Responsibility

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

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

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

Contact Information

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

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

Tel: 800-874-9789 / 609-587-9797
Fax: 609-587-1970

Customer Support E-mail: techsupport@princetoninstruments.com

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

America	1.877.4.PIACTON (877.474.2286)
Benelux	+31 (347) 324989
France	+33 (1) 60.86.03.65
Germany	+49 (0) 89.660.7793
Japan	+81 (3) 5639.2741
UK & Ireland	+44 (0) 28.3831.0171

Otherwise, see our Support web page at www.princetoninstruments.com. An up-to-date list of addresses and telephone numbers is posted on the www.princetoninstruments.com/Support page. In addition, links on this page to support topics allow you to send e-mail based requests to the Customer Support group..

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