Spec-10® System

Princeton Instruments

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Chapter 1

Introduction

Description

The Spec-10 family of detectors incorporates performance-optimized spectrometric CCDs, ultra-low-noise electronics, and full software control of both detector and spectrometer to produce a detection system that delivers the data you need. A Spec-10 system can be configured with a number of front- and back-illuminated scientific-grade CCDs (including eXcelon^{TM} enabled back-illuminated CCDs) that are available only from Princeton Instruments. These exclusive detectors, developed jointly with CCD manufacturers, employ several design features engineered specifically towards optimizing performance parameters for spectroscopic experiments. The most obvious special characteristic, the rectangular array format of the CCDs, serves the dual purpose of providing fast spectral rates (small heights) and full spectral coverage (large widths).

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

- **Improved sensitivity** – improved QE over broader wavelength region compared to back-illuminated sensors,

- **Reduced etaloning** – up to 10 times lower etaloning or unwanted fringes in near infrared (NIR) region compared to standard back-illuminated CCDs,

- **Lower dark current** – similar to back-illuminated CCDs or 100 times lower than the deep depletion CCDs.

System Components

Standard Components

All Spec-10 systems consist of standard hardware and software as well as appropriate interface hardware for your computer system. Some systems also include optional hardware.

Optional System Components

Optional items include an internal shutter (LN-cooled detectors only), spectrometer mount adapters, dual digitization capability, and a Caron Chilled Coolant Circulator for TE-cooled systems.

Figure 1. Standard Components

Application Software

Spec-10 detectors run under WinSpec/32, Princeton Instruments' 32-bit Windows®
software package for spectroscopy. WinSpec/32 provides comprehensive spectral
acquisition, display, processing, and archiving functions — so you can perform complete
data acquisition and analysis without having to rely upon third-party software. WinSpec
gives you the ability to run automatic spectrometer control and calibration routines, as
well as to move to any spectral window or change gratings without having to recalibrate.
WinSpec also facilitates snap-ins to permit easy user customization of any function or
sequence. Windows DLLs are available to allow you to write your own software, making
integration of the detection system into larger experiments or instruments a
straightforward endeavor.

About this Manual

Manual Organization

This manual provides the user with all the information needed to install a Spec-10
detector and place it in operation. Topics covered include a detailed description of the
detector, installation, cleaning, specifications and more.

Note: 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.

Chapter 1, Introduction briefly describes the Spec-10 family of detectors; details
the structure of this manual; and documents environmental, storage, and cleaning
requirements.

Chapter 2, System Component Descriptions provides descriptions of each
system component.

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

Chapter 4, System Setup provides detailed directions for mounting the detector
to a spectrometer and for interconnecting the system components.

Chapter 5, Operation includes a simple procedure for verifying system operation
and discusses operational considerations associated with exposure, readout, and
digitization.

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

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

Appendix A, Specifications includes computer, controller and detector
specifications.

Appendix B, Outline Drawings includes outline drawings of the Spec-10
detectors and the ST-133A and ST-133B Controllers.

Appendix C, Spectrometer Adapters provides mounting instructions for the
spectrometer adapters available for Spec-10 detectors.

Appendix D, 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 Spec-10 systems (LN-, NTE-, NTE 2-, TEA-, XTE-cooled and lifetime vacuum XP).

Warranty and Service provides the Princeton Instruments 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.

ESD Precautions

The CCD and other system electronics are extremely sensitive to electrostatic discharge (ESD). To avoid permanently damaging the system, please observe the following precautions:

- When using high-voltage equipment (such as an arc lamp) with your Spec-10 system, be sure to turn the controller power *on last* and power the controller *off first*.

- Use caution when triggering high-current switching devices (such as an arc lamp) near your system. Transient voltage spikes can permanently damage the CCD. 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 Spec-10 system is powered on. An unconnected cable segment can become electrically charged and can damage the CCD if reconnected.

- Connect the detector-controller cable to the controller before connecting the cable to the detector.

- Disconnect the detector-controller cable from the detector before disconnecting it from the controller.

Additional Precautions

Detector and Controller

- If the equipment is damaged, the protective grounding could be disconnected. Do *not* use damaged equipment until its safety has been verified by authorized personnel. Disconnecting the protective earth terminal, inside or outside the apparatus, or any tampering with its operation is also prohibited. Never impede airflow through the equipment by obstructing the air vents. Allow at least one-inch air space around any vent.

- Do not "mix and match" detectors and controllers.

- Prevent array saturation while data is not being acquired by completely closing the entrance slit to the spectrometer (especially when a shutter is not used).

- Protect a UV-scintillator-coated CCD from excessive exposure to UV radiation. This radiation slowly bleaches the scintillator, reducing sensitivity.

- If an LN-cooled detector is being operated under high humidity conditions, periodically clean the outside of the valves so ice buildup does not prevent the valves from venting normally.

- Operating liquid-assist TE-cooled detectors in high humidity environments can produce condensation inside the detector's electronic enclosure. Damage from humid condensation may not be covered by the product warranty.

Shutter

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

Spectrometer Support

Princeton Instruments offers extensive support for spectrometer integration, including fiberoptic accessories, lenses, lens mounts, f# matchers, and spectrometer flanges. The Spec-10 detector can be coupled to Roper Scientific's entire line of Acton Research spectrometers, providing fully integrated instruments that offer automated software control of both spectrometer and detector. Adapters are also available for most other spectrometers.

Enhancement Coatings

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

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.

Detector and Controller

Although there is no periodic maintenance that *must* be performed on the Spec-10 detector or the controller, users are advised to wipe it down with a clean damp cloth from time to time. This operation should only be done on the external surfaces and with all covers secured. In dampening the cloth, use clean water only. No soap, solvents or abrasives should be used. Not only are they not required, but also they could damage the finish of the surfaces on which they are used.

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 Spec-10 detector system contains no user-serviceable parts, repairs must be done by Princeton Instruments. Should your system need repair, contact Princeton Instruments customer service for instructions (telephone, e-mail, and address information are provided on page 146 of this manual).

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

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Chapter 2
System Component Descriptions

Spec-10 Detector

CCD Array: The Spec-10 system can be configured with a number of high performance, rectangular-format, front- and back-illuminated scientific grade CCDs (including eXcelon^{TM} enabled back-illuminated CCDs), some of which are exclusive to Princeton Instruments. The arrays employ several design features engineered specifically towards optimizing performance parameters for spectroscopic experiments.

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

Window: The detector window is made of SI-UV fused silica quartz.

Internal Shutter: LN-cooled Spec-10 detectors can incorporate an internal shutter. It is important to realize the limitations of the shutter, including its mechanical lifetime (typically a million cycles or more). Avoid running the shutter unnecessarily and avoid using shorter exposure time and higher repetition rates than are required. If a shutter does stop working, contact the factory.

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

Connectors:

Controller: Power, control signals, and data are transmitted between the ST-133 and the Spec-10 detector via the 25-pin D connector located on the rear of the detector. The Detector-Controller cable is secured by a slide-latch 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: (NTE/NTE 2/XP/XTE only) There may be a fan located inside the detector'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 heat produced by the Peltier device is then removed by the air drawn into the detector by the internal fan and exhausted through the side covers. 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: Several of the thermoelectrically-cooled detectors are available with optional liquid-assisted or liquid-only cooling. Two coolant ports are provided on the sides of these detectors. These quick-disconnect ports require 1/4" thin-wall plastic tubing or 3/8" I.D. thick-wall PVC tubing, depending on the Spec-10 model. Instructions for setting up coolant flow are provided on page 40.

Dewar: LN-cooled detectors 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 detector holds 2.2 liters of liquid nitrogen (LN).

An "all-directional" Dewar is 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.

Adapters: A variety of spectrograph adapters are available from Princeton Instruments. Refer to Appendix C for information about mounting these adapters to your spectrometer and detector.

ST-133 Controller

Electronics: The ST-133 controller is a compact, high performance CCD Detector Controller for operation with Princeton Instruments brand[*] detectors. Designed for high speed and high performance image acquisition, the ST-133 offers data transfer at speeds up to 5 megapixel per second and 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.

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[*] 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, NTE, or XTE detector *cannot* be used with an LN detector.

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 is located on the on the front panel and 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 shows the two locations.
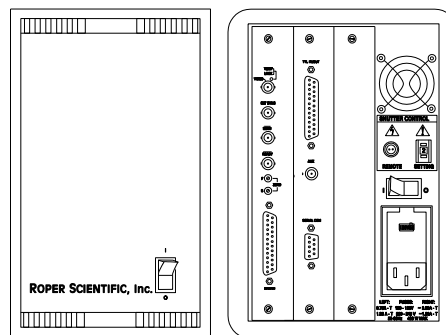
Figure 2. Power Switch Location (ST-133A and ST-133B)

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 back-plane 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 are described on the following page. Removing and inserting boards is described in Chapter 7, pages 89-90

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 **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 detector and controller or serious damage to the CCD may result. This damage is *NOT* covered by the manufacturer's warranty.

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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 ± 0.05°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. Note that video output is not currently supported under USB 2.0. If labeled Aux, this output is reserved for future use.
3	**External Sync Input:** TTL input that has a 10 kΩ pullup resistor. Allows data acquisition and readout to be synchronized with external events. Through software, positive or negative (default) triggering can be selected.
4	$\overline{SCAN}$ **Output:** WinSpec/32 (ver. 2.4 and higher) software-selectable NOT SCAN or SHUTTER signal. Default is SHUTTER.

Figure 3. ST-133 Rear Panel Callouts

#	Feature	#	Feature
5	$\overline{READY}$ **Output:** Initially HIGH. Changes state on completion of cleaning cycles before the first exposure.	11	**Fan:** Cools the controller electronics. Runs continuously when the controller is turned on.
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.	12	**Shutter Setting Selector:** Sets the shutter hold voltage. Dial is correctly set at the factory for the detector's internal shutter if one is present. Refer to Table 4, on page 36 for the shutter setting appropriate to your system.
7	**Detector Connector:** Transmits control information to the detector and receives data back from the detector via the Detector-Controller cable.	13	**Remote Shutter Connector:** Provides shutter-drive and hold voltages for a Princeton Instruments 25 mm external shutter (typically, an entrance slit 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 Input 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. Uses TAXI protocol.	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- or 6050-0361 for LN-cooled detector) 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 rear of the Spec-10 detector. The Detector-Controller cable is also available in 6', 15', 20', and 30' lengths.

Interface Cable: Depending on the system configuration, either a USB or a TAXI 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) 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 WinSpec/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: This interface card is required when the system interface uses the USB 2.0 protocol rather the 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

WinSpec/32: Princeton Instruments' 32-bit Windows® software package for spectroscopy. It provides stand-alone comprehensive spectral acquisition, display, processing, and archiving functions. WinSpec gives you the ability to run automatic spectrometer control and calibration routines, as well as to move to any spectral window or change gratings without having to recalibrate. WinSpec also features snap-ins and macro record capability to permit easy user customization of any function or sequence.

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

Scientific Imaging ToolKit™ (SITK™): A collection of LabVIEW® VIs for scientific detectors and spectrographs. This third party software can be purchased from Princeton Instruments.

User Manuals

Spec-10 System User Manual: This manual describes how to install and use the Spec-10 system components.

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

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 25
2. Verify that all system components have been received.	Chapter 4 System Setup, page 25
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 28
4. If the WinSpec/32 software is not already installed in the host computer, install it.	WinSpec/32 manual
5. If the appropriate interface card is not already installed in the host computer, install it.	Chapter 4 System Setup, page 29 (TAXI-PCI) or page 30 (USB)
6. Mount the Detector to the spectrometer.	Chapter 4 System Setup, page 33
7. With the Controller power turned OFF, connect the Detector-Controller cable to the DETECTOR connector on the rear of the Controller. Adjust the slide latch so the cable connection is locked.	Chapter 4 System Setup, page 37 Chapter 15 Troubleshooting, page 91
8. With the Controller power turned OFF, connect the Detector-Controller cable to the appropriate connector on the rear of the Detector. Then tighten down the locking hardware (lock screws or slide-latch depending on detector and cable used).	Chapter 4 System Setup, page 37
9. With the Controller and computer power turned OFF, connect the interface cable (TAXI or USB) to the Controller and the interface card in the host computer. Then tighten down the locking hardware.	Chapter 4 System Setup, page 37
10. With the Controller power turned OFF, connect the Controller power cable to the rear of the controller and to the power source.	
11. Turn the Controller ON.	

Action	Reference
12. Turn on the computer and begin running WinSpec/32. When the computer boots, you may be asked for the location of the interface drivers.	Chapter 4 System Setup, page 29 (PCI drivers) or page 30 (USB drivers)
	WinSpec/32 manual
13. In WinSpec/32, run the Camera Detection wizard or load the defaults from the controller.	Chapter 5 Operation
	WinSpec/32 manual
14. Set the target array temperature.	Chapter 5 Operation, page 54
15. If the system is cooled by coolant circulation, make the tubing connections between the coolant circulator and the detector.	Chapter 4 System Setup, page 40
16. If the system is cryogenically cooled, fill the Dewar.	Chapter 5 Operation, page 41
17. When the system reaches temperature lock, wait an additional 30 minutes and then begin acquiring data in focus mode.	Chapter 5 Operation, page 49
18. Adjust the focus for the best spectral lines. If you are using WinSpec/32, you may want to use the Focus Helper function for this purpose.	Chapter 5 Operation, page 49
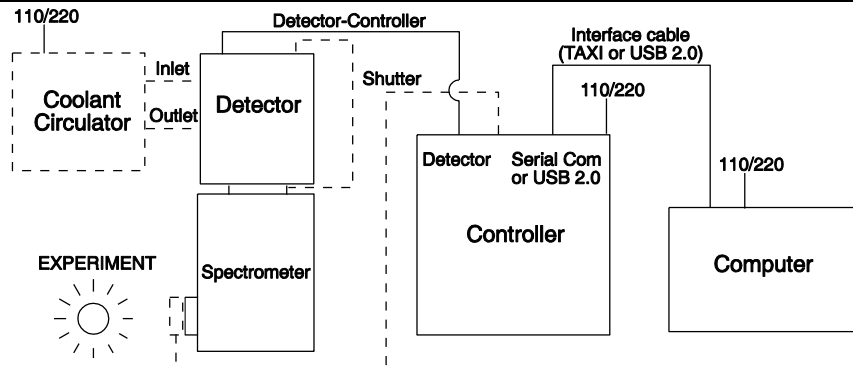
Figure 4. System Diagram: TE-cooled Detector
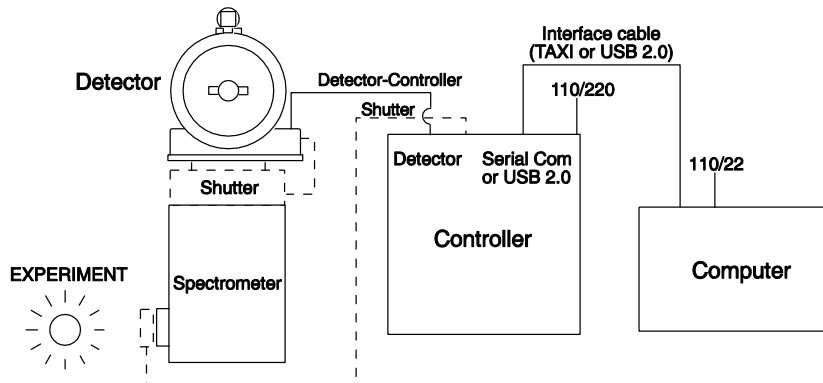
Figure 5. System Diagram: LN-cooled Detector

Chapter 4
System Setup

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 detector or controller specifications cannot be achieved, internal damage may have occurred in shipment. Please save the original packing materials so you can safely ship the detector system to another location or return it to 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 Spec-10 system. A complete system consists of:

- Detector (TE- or LN-cooled).
- ST-133 Controller (TAXI or USB Interface Control Module)
- Detector-Controller cable: DB25 to DB25 cable (6050-0321 is standard for TE-cooled detectors; 6050-0361 is standard for LN-cooled detectors).
- Computer: Can be purchased from Princeton Instruments or provided by user.
- WinSpec CD-ROM
- User Manuals
- Interface Dependent Components:
    - 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
    - Interface Card: Princeton Instruments (RSPI) High Speed PCI Interface board for TAXI interface. USB 2.0 board for USB 2.0 interface is user-provided: native USB 2.0 support on the motherboard or USB 2.0 Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop computers; SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop).

System Requirements

Environmental
Storage temperature: $\leq 55°C$;

Operating environment temperature: 5ºC to +30ºC; for NTE/NTE 2 Detectors, the environment temperature range over which system specifications can be guaranteed is +18ºC to +23ºC

Relative humidity: <50% noncondensing. High humidity climates may require continuous flushing of the spectrometer's exit port with nitrogen. If LN-cooled detectors are operated under high humidity conditions, ice-buildup could occur around the vent valves. Operating liquid-assist TE-cooled detectors in high humidity environments can produce condensation inside the detector's electronic enclosure. Damage from humid condensation may not be covered by the product warranty.

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: The internal fan is 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.

Spec-10 detectors 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 Spec-10 detector 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:

- 2 GHz Pentium® 4 (or greater).
- Windows® 95, Windows® 98SE, Windows® ME, Windows NT®, Windows® 2000, or Windows® XP operating system.

  Note: WinSpec/32 versions 2.5.22-2.5.23 operate under Windows 2000 and later (32-bit only). Versions 2.5.25 and later operate under Windows XP (32-bit with SP3 or later) and Windows Vista® (32-bit).

- 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 1 GB RAM (or greater).
- CD-ROM drive.
- Hard disk with a minimum of 1 Gbyte available. A complete installation of the program files takes about 17-50 Mbytes and the remainder is required for data storage, depending on the number and size of images/spectra collected. Disk level compression programs are not recommended. Drive speed of 10,000 RPM recommended.
- Super VGA monitor and graphics card supporting at least 65535 colors with at least 128 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- Two-button Microsoft compatible serial mouse or Logitech® three-button serial/bus mouse.

USB 2.0 Protocol:

- 2 GHz Pentium® 4 (or greater).
- Windows 2000 (with Service Pack 4), Windows XP (with Service Pack 1) or later operating system.

  Note: WinSpec/32 versions 2.5.22-2.5.23 operate under Windows 2000 and later (32-bit only). Versions 2.5.25 and later operate under Windows XP (32-bit with SP3 or later) and Vista (32-bit).

- Native USB 2.0 support on the motherboard or USB Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop computers; SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop).
- Minimum of 1 GB RAM (or greater).
- CD-ROM drive.
- Hard disk with a minimum of 1 Gbyte available. A complete installation of the program files takes about 17-50 Mbytes and the remainder is required for data storage, depending on the number and size of images/spectra collected. Disk level compression programs are not recommended. Drive speed of 10,000 RPM recommended.

- Super VGA monitor and graphics card supporting at least 65535 colors with at least 128 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.
- Mouse or other pointing device.

Verifying Controller Voltage Setting

The ST-133's power requirements are discussed in Appendix A. Note that the Spec-10 power requirements are entirely provided by the ST-133 via the Detector-Controller cable.

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 correct fuses for the country where the ST-133 is to be shipped are installed at the factory.

Figure 6. Controller Power Module

Note: On ST-133s, the voltage ranges and fuse ratings may be printed above or below the 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 79 for changing the voltage setting and fuses.

Installing the Application Software

Installation is performed via the WinSpec/32 installation process. If you are installing WinSpec for the first time, you should run the installation before installing the interface card in the host computer. On the **Select Components** dialog box (see Figure 7), click on the **AUTO PCI** button to install the interface card drivers (Princeton Instruments (RSPI) PCI and 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.
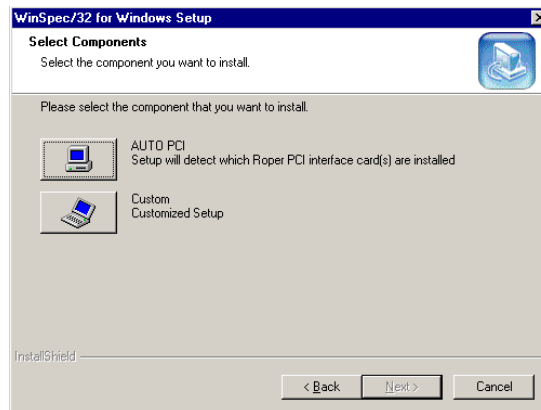
Figure 7. WinSpec Installation: Interface Card Driver Selection

Setting up the Communication Interface

Setting up a PCI Interface

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

A Princeton Instruments (RSPI) high speed 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 are available) and the digitization rate may be as high as 5 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 WinSpec/32 software, either **High Speed PCI** or **PCI(Timer)** can be the selected 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 7 "Troubleshooting", page 87 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 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, 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, Windows® XP and Windows Vista® 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 (EZ-DLLS).

- Some WinSpec 2.5.X features are not fully supported with USB 2.0. Refer to Appendix D, page 133, 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 (Microsoft is the provider). 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 Spec-10 system (see page 27).
> - 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 WinSpec/32 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, WinSpec/32 automatically put the required INF, DLL, and USB driver file in the "Windows" directories shown below. Refer to Table 2 for the appropriate file names and 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

Mounting to a Spectrometer

The detector must be properly mounted to the spectrometer to take advantage of all the available grouping features. Depending on the spectrometer and detector 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 Spec-10 detector and spectrometer combinations, all of the adapter mounting instructions are located in Appendix C. Refer to the table at the beginning of that appendix to find the instruction set appropriate to your system.

WARNING! If the detector is LN-cooled, it must never be tilted more than 30° from vertical, unless the "all-directional" Dewar option has been purchased. For this reason, an end-on type and a side-on type 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 as follows. Note that the "Mounting Flange to Focal Plane" distance is without a shutter or adapter.

Cooling	Reference Points	Distance
LN	Front of Shutter to Focal Plane	0.894 ± .01"
LN	Front of 7050-0032 Large Detector Adapter to Focal Plane	0.549 ± .01"
NTE/XP	Mounting Flange to Focal Plane	0.593 ± .01"
NTE 2/XTE	Mounting Flange to Focal Plane	0.599 ± .01" (mechanical)
		0.639 ± .01" (optical)
Note: The large shutter has a 3.88" bolt circle. The 7050-0032 adapter, all PDAs, and ICCDs have a 3.60″ bolt circle.		

Table 3. Focal Plane Distances

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 +.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

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

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

To Determine Orientation (Internal Shutter Present):

1. Turn the controller on.

2. Turn off the cooling. In the case of an ST-133 controller and running WinSpec software, simply set the highest possible array temperature (25°C).

3. Open the shutter. With an ST-133 controller and using the WinSpec software, select the shutter OPENED mode at the software.

4. Look in the front window of the CCD to determine the long axis of the CCD. Exposure to room light will not damage the CCD.

Detector-Spectrometer Adapters

Princeton Instruments has a variety of adapters for mating Spec-10 detectors to spectrometers. In some cases, the appropriate adapter is mounted to the detector 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 C for mounting instructions.

Setting up a Shutter

Introduction

The <u>standard</u> LN-cooled and TE-cooled Spec-10 detectors do not contain internal shutters. However, an optional 40 mm internal shutter is available for LN-cooled detectors and must be specified at time of order. If you have a detector without an internal shutter, you can purchase a Princeton Instruments 25 mm external shutter, typically used at the entrance slit of a spectrograph.

Internal Shutter

The Shutter Setting is set at the factory for the detector's internal shutter if one is present. Because the detector and its controller are shipped as a system, this setting should not need to be changed. Additionally, the default shutter type (on the **Hardware Setup|Controller/Camera** tab page in WinSpec) should not need to be changed.

To Set up a 40 mm Internal Shutter:

1. Verify that the ST-133 is OFF.

2. Remove the twist tie from the shutter cable.

3. Connect the shutter cable to the **Shutter Power** connector on the detector (on the side of the electronics box on the LN-cooled detector).

4. On the back of the ST-133, select shutter setting "**5**" via the Shutter Setting push switch. Press the "-" or the "+" button until the correct setting is displayed in the window. This switch sets the shutter hold voltage for the shutter.

Figure 8. Shutter Setting for LN Detector 40 mm Internal Shutter

5. After you turn on the ST-133 and open WinSpec, go the **Hardware Setup|Controller/Camera** tab page and verify that "**Large**" is the selected **Shutter Type**. The shutter compensation time for this shutter is approximately 28 ms.

WARNING!

External Shutter

Dangerous live potentials are present at the Remote **Shutter Power** connector. To avoid shock hazard, turn the Controller power OFF (OFF = 0, ON = |) before connecting or disconnecting the shutter cable.

To Set up a Princeton Instruments-supplied 25 mm External Shutter:

1. Verify that the ST-133 is OFF.

2. Bolt the entrance slit shutter assembly to the entrance slit of the spectrograph. The entrance slit shutter mount used with Acton and TRIAX/SPEX spectrometers requires no disassembly (Figure 9).

3. Connect the shutter cable to the **Shutter Power** connector on the detector (on the back of a TE-cooled detector or on the side of an LN-cooled detector) or to the **Shutter Power** connector on the ST-133. In many systems, cable length considerations will make it more convenient to connect to the Shutter Power connector on the detector.

Figure 9. Entrance Slit Shutter Mount

4. On the back of the ST-133, select shutter setting "**1**" via the Shutter Setting push switch. Press the "-" or the "+" button until the correct setting is displayed in the window. This switch sets the shutter hold voltage for the shutter.

5. After you turn on the ST-133 and open WinSpec, go the **Hardware Setup|Controller/Camera** tab page and select "**Remote**" as the **Shutter Type**. The shutter compensation time for this shutter is approximately 8 ms.

Shutter Setting

Caution

The wrong setting may cause the shutter to malfunction or be damaged. An ST-133 with the 70 V Shutter option (used only with the 35 mm shutter) cannot be used with a detector having a different shutter, even by selecting a different number, because the shutter could be permanently damaged by the high voltage and larger stored energy required to hold the 70 V shutter open.

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 (optional for Spec-10 LN-cooled detectors)
* Shutter settings 0, 3, and 6-9 are unused and are reserved for future use.	

Table 4. ST-133 Shutter Drive Selection

Connecting the Detector-Controller Cable

Caution   Turn the Controller power OFF (OFF = 0, ON = |) before connecting or disconnecting
the Detector-Controller cable.

To Connect the Detector-Controller Cable:

1. Verify that the controller power is OFF.

2. Connect the male end of the Detector-Controller cable to the "Detector" port on
   the rear of the Controller. Refer to "***Securing the Detector-Controller Cable Slide
   Latch"***, page 91.

3. Lock the connector in place.

4. Connect the female end of the cable to the detector.

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.

Connecting the Interface (Controller-Computer) Cable

TAXI® Cable

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

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.

Entering the Default Camera System Parameters into WinSpec

Software changes implemented in WinSpec 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.

WinSpec 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 WinSpec. 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 10), leave the checkbox unselected and click on **Next**.
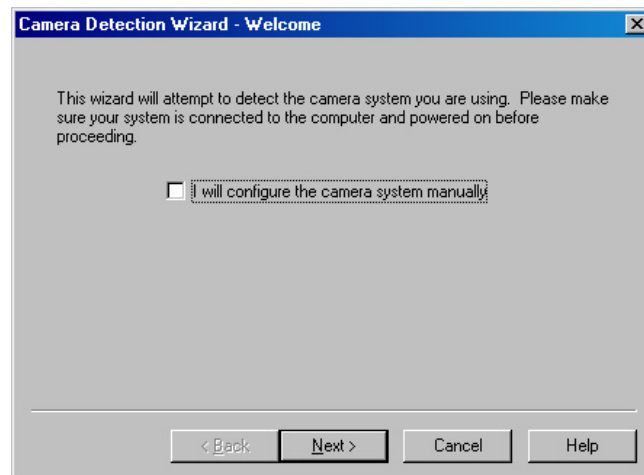
Figure 10. Camera Detection Wizard - Welcome dialog box

4. 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.

WinSpec Versions before 2.5.19.6: Run RSConfig.exe

1. Make sure the ST-133 is connected to the host computer and that it is turned on.

2. Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed WinSpec.

3. When the RSConfig dialog box (Figure 11) 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 84.
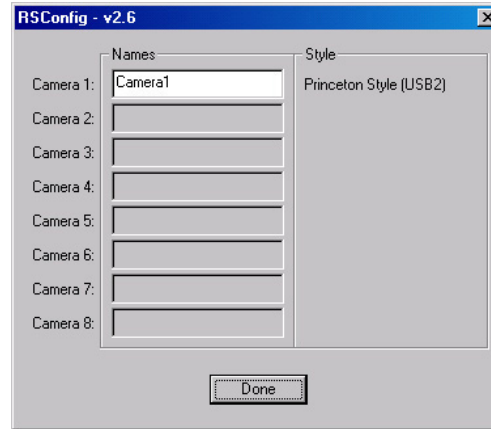
Figure 11. RSConfig dialog box

4. Open WinSpec and, from **Setup|Hardware…,** run the Hardware Setup wizard.

5. When the PVCAM dialog box (Figure 12) 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 12. Hardware Setup wizard: PVCAM dialog box

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

Making the Coolant Circulator-Detector Connections

Caution

1. Do not use any coolant fittings other than those supplied by Princeton Instruments. Although standard pipe fittings are similar, in most cases they are not the same. Forcing these fittings into the cooling block will permanently damage the threads.

2. Spec-10 detectors 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 detector 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 Spec-10 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. The directions below are for two tubing sizes. Follow the directions appropriate to your detector.

   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 detector use a ferrule-less quick-disconnect method of securing the tubing and that both the detector'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 13.

   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 13) 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 13.

1) Insert the male quick-disconnect (on tubing) into the appropriate female quick-disconnect on the detector (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 13) and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.
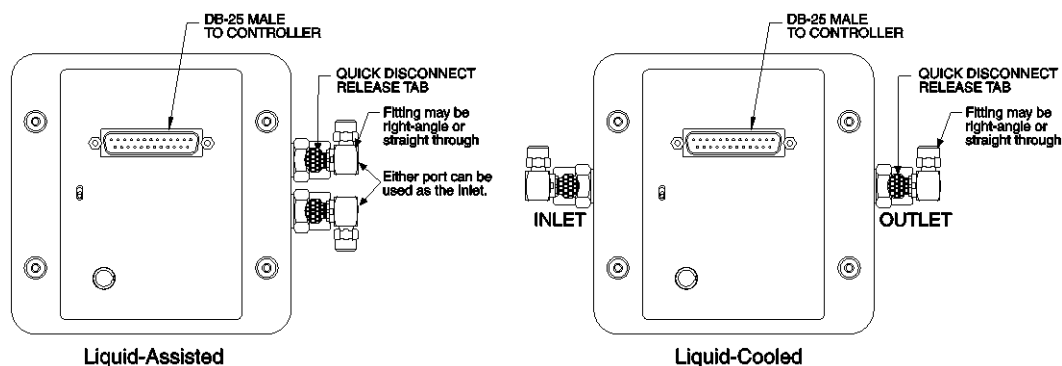
Figure 13. Coolant Ports

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).

Filling the Dewar (LN-cooled Detectors)

Caution | Cryogenically-cooled detectors, 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 detector to room temperature.

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 Dewar port cap if there is LN present in the Dewar. Pressure due to nitrogen gas can cause the cap to fly out when the retaining nut is loosened, possibly spraying you with liquid LN, which can cause severe injury.

Procedure
To Fill the Dewar

1. Loosen the retaining nut (Figure 14) a few turns, then remove the LN Dewar port cap by pulling it straight out.

Dewar Filler Cap

Retaining Nut

Pressure Relief Valves
1 psi and 10 psi

Venting Safety Bell

Figure 14. Dewar Ports and Valves

2. It is recommended that you use an LN transfer Dewar with a pouring spout to transfer LN from the storage tank to the detector. 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.

3. 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.

4. Fill up the Dewar (approximately 1.7 liters for the standard Dewar, or 0.85 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 and then remove it. The LN level will be indicated by the condensation on the wire.

   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.

   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.

5. 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 detector is being operated under high humidity conditions. If frost appears on the valves, periodically clean the outside of the valves so that ice does not prevent the valves from venting normally.

6. Set the desired temperature via the **Detector Temperature** dialog box in WinSpec. 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**. (Also, the **Temp Lock** LED on the back of the ST-133 will light to indicate that the temperature is thermostated to within ±0.050°C.) An LN-cooled CCD normally reaches -100°C within 45-55 minutes.

   Notes:

   1. Temperature regulation does not reach its ultimate stability for at least 30 minutes after temperature lock has been achieved. After this period of time the desired temperature is maintained with great precision.

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

Caution The pressure relief valves (Figure 14) 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* and allow the Dewar to warm up to room temperature. Then contact Princeton Instruments Customer Support for further instructions.

Holding Times

Table 5 lists the approximate hold times for the standard side-on 1.7 liter Dewar at the lowest temperature setting.

CCD Array	Dewar Hold Time
1340x100, 100B, 100R, 100BR	> 35 hours
1340x400, 400B	> 30 hours
1340x400R, 400BR	> 36 hours

Table 5. CCD Array vs. Dewar Hold Time

To maximize the holding time when leaving the detector overnight, in addition to topping off the Dewar, you will want to turn off the heater switch by setting the array temperature to its lowest operating temperature, typically -120° C, through the software. *You must leave the controller power on in either case.* This will bring the CCD to its minimum operating temperature and will minimize LN evaporation. The following day, set the temperature to the operating temperature via the Detector Temperature dialog box in the WinSpec software.

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Chapter 5

Operation

Introduction

Once the Spec-10 detector has been installed as explained in the preceding chapters, operation of the detector is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinSpec/32), set the target detector temperature, wait until the temperature has stabilized (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 data is displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in Figure 15.
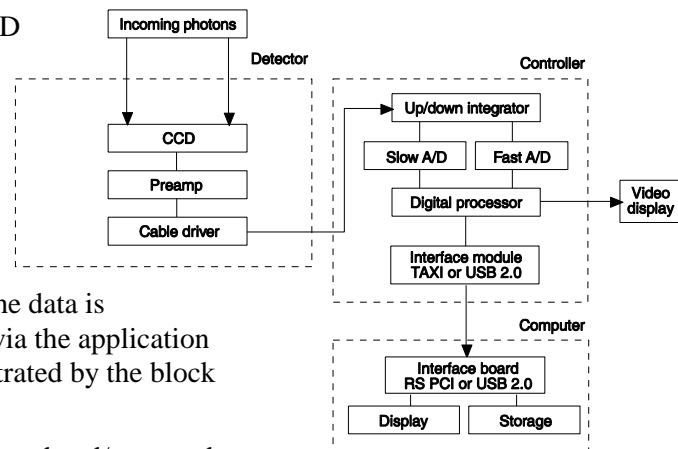
Figure 15. Block Diagram of Light Path in System

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 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"*** section) 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 the *"First Light"* procedure for spectroscopy applications follow: this procedure provides 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 and System On/Off Sequences

The following on/off sequences are specific to the USB 2.0 interface:

1. The ST-133 must be turned on before WinSpec/32 is opened to ensure communication between the controller and the computer. If WinSpec is opened and the ST-133 is off, 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 WinSpec, turn on the ST-133, and reopen WinSpec before you can set up experiments and acquire new data.

2. WinSpec/32 must be closed before turning off the ST-133. If you turn off the ST-133 before closing WinSpec, the communication link with the controller 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 WinSpec, turned on the ST-133, and then re-opened WinSpec.

First Light

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™ 2300i (SP2300i) on which it has been properly installed. *Refer to Appendix C, "Spectrometer Adapters", for mounting instructions.* A suitable light source, such as a mercury pen-ray lamp, should be mounted in front of the entrance slit of the spectrograph. Any light source with line output can be used. *Standard fluorescent overhead lamps have good calibration lines as well.* If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0 nm for alignment purposes.

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

Assumptions

The following procedure assumes that

1. You have already set up your system in accordance with the instructions in Chapter 3, Chapter 4, and Appendix C.

2. You have read the previous sections of this chapter.

3. You are familiar with the application software.

4. The system is air-cooled. If your system is designed for liquid-assisted TE-cooled or for LN-cooled operation, be sure to read *"Cooling the CCD"*, starting on page 52 before running the circulator or filling the Dewar.

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. Turn on the controller power.

    Note: The detector overload alarm may sound briefly and then stop. This is normal and is not a cause for concern. However, if the alarm sounds continuously, even with no light entering the spectrograph, something is wrong. Turn off the power and contact the factory for guidance.

3. Turn on the computer power.

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

4. Start the application software.

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:** If you are using the USB 2.0 interface, verify that the box is checked.

  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 Large.

- **Readout mode:** Full frame.

Detector Temperature (Setup|Detector Temperature…): -45°C

The temperature should drop steadily. When the array temperature reaches the set temperature, the green **Temp Lock** LED on the rear of the ST-133 will light and there will be a **locked** indication at the computer monitor, Note that some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within ±0.05°C.

Notes:

1. Some overshoot may occur. This could cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction.

2. 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.
- Clicking on **Store** will store the Pattern so it can be reused at another time.

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

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

Focusing

The detector mounting hardware provides two degrees of freedom, focus and rotation. In this context, focus means to physically move the detector back and forth through the focal plane of the spectrograph. The approach taken is to slowly move the detector in and out of focus and 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 2300I 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 WinSpec, 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 2300i:** 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).

Data Collection

1. After you have achieved focus, you can stop running in **Focus** mode.

2. Make any required changes to your experiment setup and software parameters. Changes might include adjusting the exposure time, setting up an entrance slit shutter, changing the timing mode to External Sync, or lowering the temperature.

3. Begin running **Acquire** mode. Data will be acquired and displayed/stored based on the experiment settings.

4. If you have completed data collection, you can leave the controller on so the array temperature will remain locked or you can go to the shutdown instructions.

Shutdown

1. Before turning off the ST-133:

   a. Empty the Dewar (if the array is cooled by LN) or stop coolant flow (if a coolant circulator or a chiller/circulator unit is being used to cool the array).

   b. Close WinSpec/32 if USB 2.0 is being used.

2. Turn off the controller.

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.

The diagram in Figure 16 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 16. The value of t_c is shutter type dependent. Because Spec-10 detectors do not usually have an internal shutter, the t_c is very small. NOT SCAN is low during readout, high during exposure, and high during shutter compensation time.
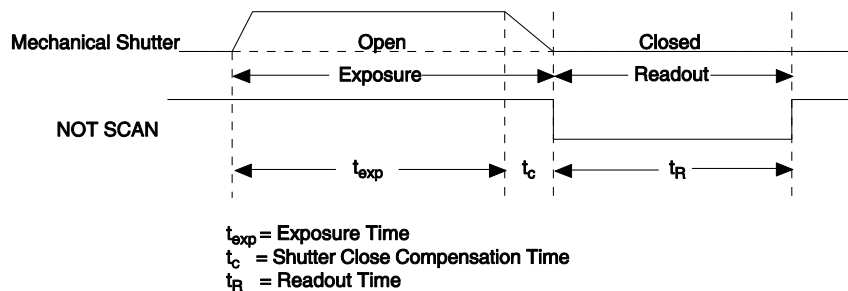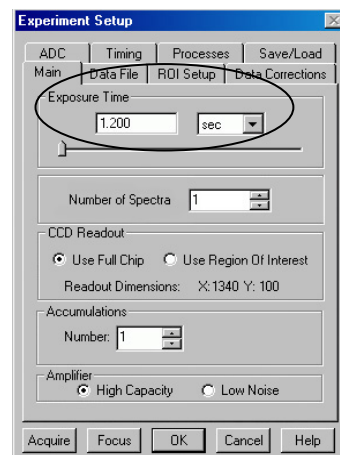

t_{exp} = Exposure Time
t_c = Shutter Close Compensation Time
t_R = Readout Time

Figure 16. Exposure of the CCD with Shutter Compensation

Continuous Exposure

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

Exposure with Shutter

If the CCD is set up for imaging mode (in WinSpec, the Imaging option has been installed and is selected on the **Experiment Setup|ROI Setup** tab 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. With an LN-cooled Spec-10 detector containing the optional internal shutter, you can use that shutter to block the light: this shutter is synchronized to the exposure-readout cycle and has a shutter compensation time (t_c) of approximately 28 ms. With a standard Spec-10 detector (shipped without an internal shutter), you need to use other ways to prevent light from falling on the array during readout.

When a detector does not have an internal shutter, you need to control the light source or use an external shutter to block light from the array during readout. If the light source can be controlled electronically via the output of the $\overline{\textbf{SCAN}}$ BNC (configured for SHUTTER output), the CCD can be read out in darkness. Another way to prevent light from falling on the array during readout is to use a ***Princeton Instruments-supplied*** 25 mm external shutter (typically used at a spectrograph entrance slit). This shutter can then be controlled by the ST-133 and would be synchronized to the exposure-readout cycle as shown in Figure 16 (shutter compensation time (t_c) is approximately 8 ms).

Cooling the CCD

As stated in the introductory chapter, detectors in the Spec-10 family can be either thermoelectrically- or cryogenically-cooled. Thermoelectrically-cooled (TE-cooled) CCD arrays can be stabilized down to -45°C with forced air. Deep-TE-cooled arrays can be stabilized down to -70 °C. XP TE air-cooled arrays can be stabilized to -80°C. XTE air-cooled arrays can be stabilized to -90°C. Liquid-cooled TE arrays can be stabilized to < -90°C because circulated coolant and an external chilling/pumping unit are used to remove waste heat. With cryogenic cooling, the array can be operated at temperatures in the range of -70°C to -120°C. Generally speaking, the lower the array temperature, the lower the dark current and, therefore, the greater the sensitivity.

Thermoelectrically-cooled detectors have three distinct sections. The front vacuum enclosure contains the CCD array seated on a cold finger. This finger is in turn seated on a multi-stage Peltier thermoelectric cooler. The back enclosure contains the heat exchanger. An internal fan cools the heat exchanger and the waste heat exits the unit through openings in the detector housing. The electronics enclosure contains the preamplifier and array driver board. This design keeps all signal leads to the preamplifier as short as possible and also provides RF shielding.

Cryogenically-cooled detectors use liquid nitrogen (LN$_2$) to reduce the temperature of the CCD. The liquid nitrogen is stored in a Dewar that is enclosed in a vacuum jacket for minimal external thermal losses. The chip temperature is regulated by a <u>heating element</u> driven by closed-loop proportional control circuitry. A thermal sensing diode attached to the cooling block of the detector monitors the chip temperature. The temperature can be thermostated over a 40° to 50° Celsius range. The exact range depends on the CCD device.

Caution

> Cryogenically-cooled detectors, 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 detector to room temperature.

Detector	Approximate Range
Spec-10:100, 100B (1340x100)	+20°C to -45°C (forced air cooled TE, coolant circulation capable); -70°C to -120°C (LN); +20°C to -80°C (forced air XP) +20°C to -100°C (forced air XTE)
Spec-10:100R, 100BR (1340x100)	-70°C to -120°C (LN); +20°C to -80°C (forced air XP) +20°C to -100°C (forced air XTE)
Spec-10:256, 256B, 256BR, 256BUV, 256E (1024x256)	+20°C to -90°C (liquid cooled TE); +20°C to -75°C (forced air cooled TE); -70°C to -120°C (LN)
Spec-10:400, 400B (1340x400)	+20°C to -45°C (forced air cooled TE, coolant circulation capable); -70°C to -120°C (LN); +20°C to -80°C (forced air XP) +20°C to -90°C (forced air XTE)
Spec-10:400BR, 400R (1340x400)	-70°C to -120°C (LN); +20°C to -80°C (forced air XP) +20°C to -90°C (forced air XTE)
Spec-10:2K, 2KB, 2KBUV (2048x512)	+20°C to -90°C (liquid cooled TE); +20°C to -75°C (forced air cooled TE); -70°C to -120°C (LN)

Table 6. Approximate Temperature Range vs. Detector

CCD Temperature Control

As stated before, lowering the temperature of the CCD will generally enhance the quality of the acquired signal. When WinSpec is the controlling software, temperature control is done via the **Detector Temperature** dialog box (see Figure 17) accessed from the **Setup** menu. Once the target (desired) array temperature has been set, the software controls the circuits in the detector so that the array temperature is reduced (thermoelectrically-cooled operation) or the array temperature

Figure 17. WinSpec/32 Detector Temperature dialog box

is raised (cryogenically-cooled operation) to the set value. On reaching that temperature, the control loop locks to the set temperature for stable and reproducible performance.
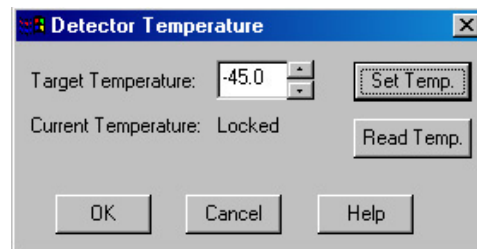
When temperature lock has been reached (temperature within 0.25°C of set value) the Detector Temperature dialog box reports that the current temperature is **Locked**. This on-screen indication allows easy verification of temperature lock. In addition, the TEMP LOCK indicator on the back of the controller lights GREEN to indicate that lock has been achieved (for more information, refer to the description of the ST-133 rear panel features, page 20).

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 6, on page 53, for typical range of 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.

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. At the typical operating temperature of an NTE/CCD detector, for example, dark charge is reduced by a factor of ~2 for every 6º reduction in temperature. In the case of detectors such as the Spec-10:100 and Spec-10:400, which have MPP type arrays, the average dark charge is extremely small. However, the dark-charge distribution is such that a significant number of pixels may exhibit a much higher dark charge, limiting the maximum practical exposure. Dark charge effect is more pronounced in the case of detectors having a non-MPP array such as the Spec-10:100BR and 400 BR.

With the light into the detector completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and detector temperature. The longer the exposure time and the warmer the detector, the larger and less uniform this background will appear. Thus, to minimize dark-charge effects, you should operate with the lowest CCD temperature possible (see *"Cooling the CCD"*, on page 52).

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. 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 detector 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 vacuum enclosure of the detector. Immediately turn off the controller (if LN-cooled, remove the liquid nitrogen also). *Then, contact the factory Customer Support Dept. for further instructions. See page 146 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 averaging, determined by either the saturation of the CCD pixels by the signal or the loss of dynamic range due to the buildup of dark charge in the pixels.

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

Figure 18. Array Terms for a CCD with Dual Output Amplifiers

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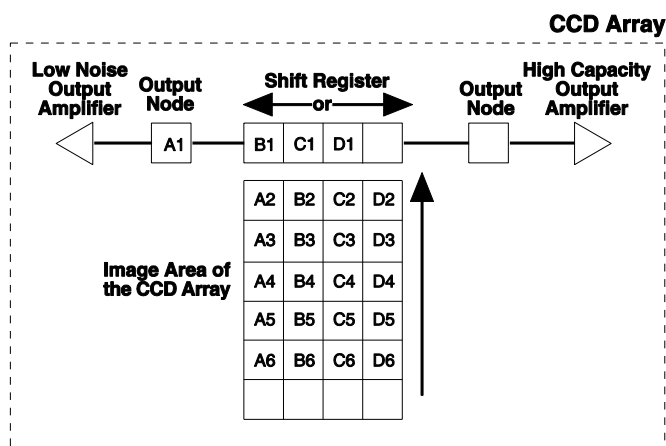
WinSpec allows you to specify the type of readout (full frame or binned), the output amplifier, and the gain (the number of electrons required to generate an ADU).

Full Frame Readout

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

The upper left drawing in Figure 19 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 Spec-10 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 19. Full Frame at Full Resolution

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

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

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

Below are the equations that determine the rate at which the CCD is read out. Tables of values for CCDs supported at the time of the printing of this manual are shown in Table 7.
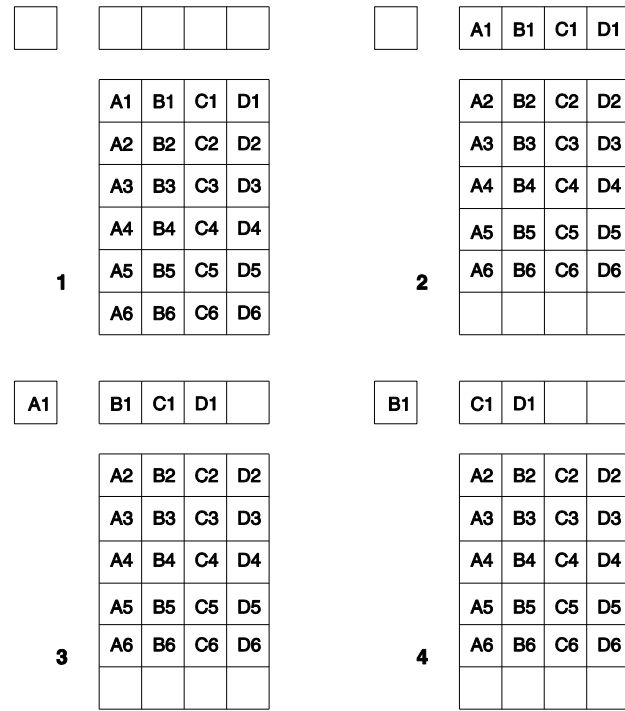
The time needed to take a full frame at full resolution is:

$$t_R + t_{\exp} + t_c \tag{1}$$

where

> t_R is the CCD readout time,
>
> $t_{\exp}$ is the exposure time, and
>
> t_c is the shutter compensation time.

The readout time is approximately given by:

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

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

The readout times for some of the Spec-10 CCD arrays are provided in Table 7 below.

CCD Array	1 MHz Readout Time (t_R)	
	Full-Frame	Binned
Spec-10:100	0.137 sec	1.97 ms
Spec-10:100B	0.137 sec	2.58 ms
Spec-10:400B	0.551 sec	13.43 ms
Spec-10:2KB	1.085 sec	20.6 ms

Table 7. Approximate Readout Time for Some Spec-10 Arrays

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

Figure 20 shows an example of 2×2 binning. Each pixel of the image displayed by the software represents 4 pixels of the CCD array. Rectangular bins of any size are possible.
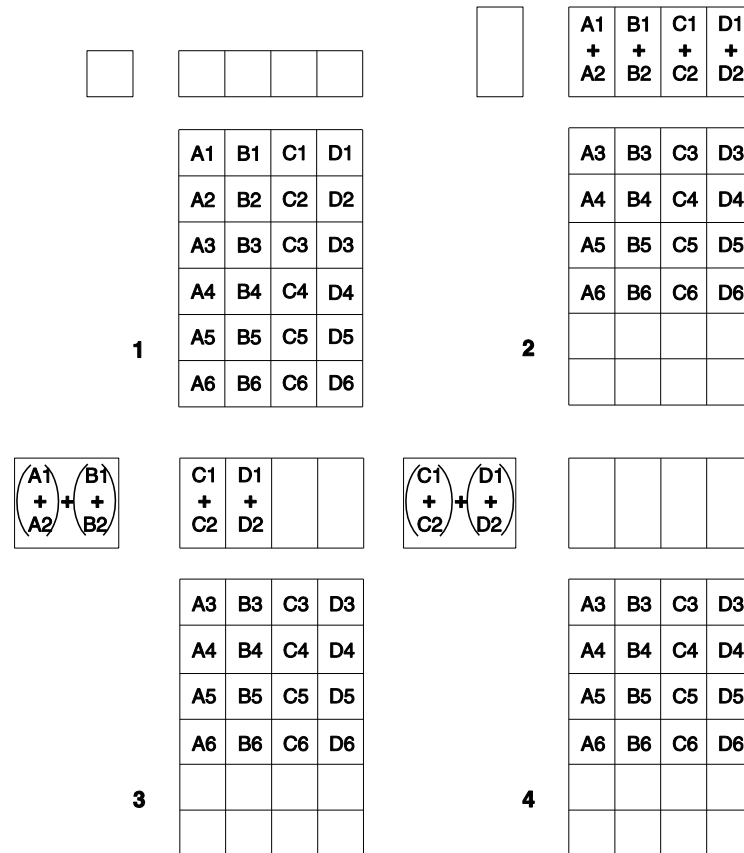
Figure 20. 2×2 Binning for Images

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

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

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

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 lost.

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

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

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

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

Output Amplifier Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Many Spec-10 systems are available with dual output nodes and amplifiers (one set at each end of the shift register as shown in Figure 18). If your system has dual output amplifiers, you can choose the array output amplifier (High Capacity or Low Noise) via WinSpec/32 on the **Acquisition| Experiment Setup…|Main** tab page.

Figure 21. Output Amplifier Selection

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

- **Low Noise amplifier:** Provides the highest sensitivity performance and is suitable when you have weak signals.

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

Analog Gain Control

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 WinSpec/32, the analog gain choices are **Low**, **Medium**, and **High**. Users who measure high-level signals may wish to
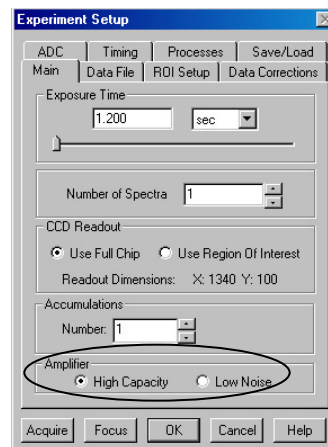
select **Low** to allow digitization of larger signals. At **Medium** gain, the detector has typically been calibrated so the overall noise is ~1 ADU RMS. This setting is suitable for experiments within the mid-level intensity range. Users who consistently measure low-level signals may wish to select **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 demonstrate the effect of changing a gain setting and do not reflect actual detector performance.

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 spectra or images 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 spectra or images do not appear to take up the fully 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**.

Analog gain is software-selectable in many of the Spec-10 cameras. In 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 detectors (see Figure 22).

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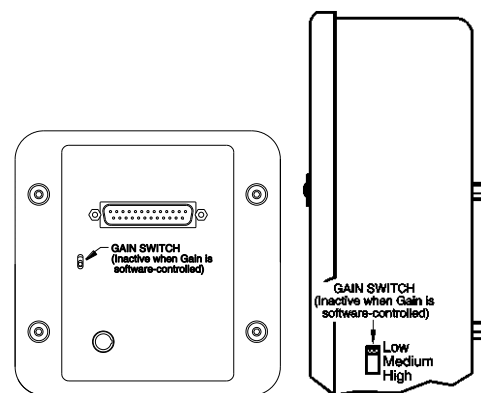

Figure 22. Analog Gain Switch on TE- and LN-cooled Detectors

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 55).

Factors associated with digitization include the digitization rate and baseline signal. Depending on the camera model, you may be able change the speed at which digitization

occurs and/or offset the baseline. These factors are discussed in the following paragraphs.

Digitization Rate

Depending on the Spec-10 model, the detector may have a single digitizer, a dual-speed digitizer that provides fast spectral rates and low-noise readout modes, or a six-speed digitizer, which enables software-selectable rates of 50 kHz, 100 kHz, 200 kHz, 500 kHz, 1 MHz, and 2 MHz.

Multiple digitization provides optimum signal-to-noise ratios at all readout speeds but because the readout noise of CCD arrays increases with the readout rate, it is sometimes necessary to trade off readout speed for high dynamic range. The faster the selected conversion speed, the faster the data collection and the higher the noise level. If noise performance is the paramount concern, selecting a slower conversion speed will typically reduce the noise level and enhance the signal-to-noise ratio. Switching between the conversion speeds is completely under software control for total experiment automation.

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 146 for contact information.*

Dark Current

Exposing the CCD to bright light ($10\times$ 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 detector to warm up to room temperature.

High Humidity

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

TE-Cooled Detectors: Operating liquid-assist TE-cooled detectors in high humidity environments can produce condensation within the detector's electronic enclosure. Damage from humid condensation may not be covered by the product warranty.

Shutter

WARNING!   *Turn the controller OFF before connecting or disconnecting the shutter cable.* Disconnecting or connecting the shutter cable to the detector while the controller is ON can destroy the shutter or the shutter drive circuitry.

TE-Cooled Detectors

There is no provision for mounting an internal shutter in a TE-cooled detector configured for spectroscopy. The detector mounts directly to the spectrometer mounting adapter leaving no room for an internal shutter. A spectrometer entrance slit shutter is available for use in spectroscopy measurements that require a shutter. Entrance slit shutters are mounted as described on page 36.

LN-Cooled Detectors

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

Summary

If the system functioned as described in *"First Light"*, you can be reasonably sure it has arrived in good working order. In addition, you should have a basic understanding of how the system hardware is used. Other topics, which are important under certain conditions, are discussed in the following chapters. See the appropriate application software manual for information on using the software to control the system.

Chapter 6

Advanced Topics

Introduction

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. Use this chart in combination with the detailed descriptions in this chapter to determine the optimal timing configuration.

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

Table 8. Detector Timing Modes

Standard Timing Modes

The basic timing modes are Free Run, External Sync, and External Sync with Continuous Cleans. 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 in the controller. 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 flow chart.

The timing diagrams are labeled indicating the exposure time (t_{exp}), shutter compensation time (t_c), and readout time (t_R). These parameters are discussed in more detail in Chapter 6.

Safe Mode

Start

Computer programs
camera with exposure
and binning parameters

Start acquisition
command sent from
computer to camera

Cleans performed

1 frame collected
as per timing mode

Stop acquisition
command sent from
computer to camera

Background or
flatfield on?   No

Yes

Background and/or
flatfield correction
performed

Frame displayed

Frames
complete?   No

Yes

Stop

Fast Mode

Start

Computer programs
camera with exposure
and binning parameters

Start acquisition
command sent from
computer to camera

Cleans performed

1 frame collected
as per timing mode

Background or
flatfield on?   No

Yes

Background and/or
flatfield correction
performed

Frames
complete?   Yes

No

During next acquisition
frames are displayed as
time permits

Stop acquisition
command sent from
computer to camera

Stop

Figure 23. Chart of Safe and Fast Mode Operation

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

Other experimental equipment can be synchronized to the detector by using the output signal (software-selectable SHUTTER or NOT SCAN) from the SCAN connector on the back of the ST-133. Shutter operation and the NOT SCAN output signal are shown in Figure 25.
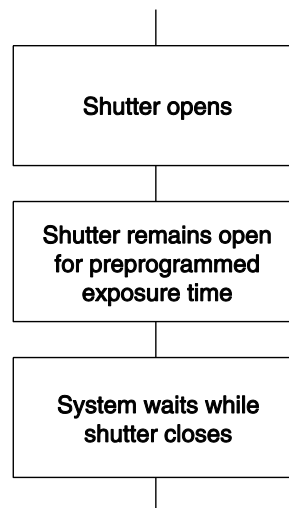
Figure 24. Free Run Timing Chart, part of the chart in Figure 23
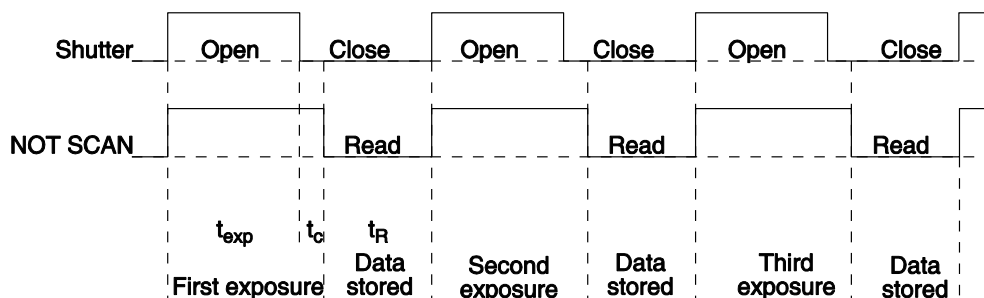
Figure 25. Free Run Timing Diagram

External Sync

In this mode all exposures are synchronized to an external source. As shown in the flow chart, Figure 26, this mode can be used in combination with Normal or PreOpen Shutter operation. In Normal Shutter mode, the controller waits for an External Sync pulse, then opens the shutter for the programmed exposure period. As soon as the exposure is complete, the shutter closes and the CCD array is read out. The shutter requires several milliseconds to open completely, depending on the model of shutter. Shutter compensation time is discussed in Chapter 6, and the table of shutter compensation times are on page 96.

Since the shutter may require up to 28 ms to fully open, the External Sync pulse provided by the experiment must precede the actual signal by at least the shutter compensation time. If not, the shutter will not be open for the entire signal, or the signal may be missed completely.

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

In the PreOpen Shutter 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 at the ST-133, 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.
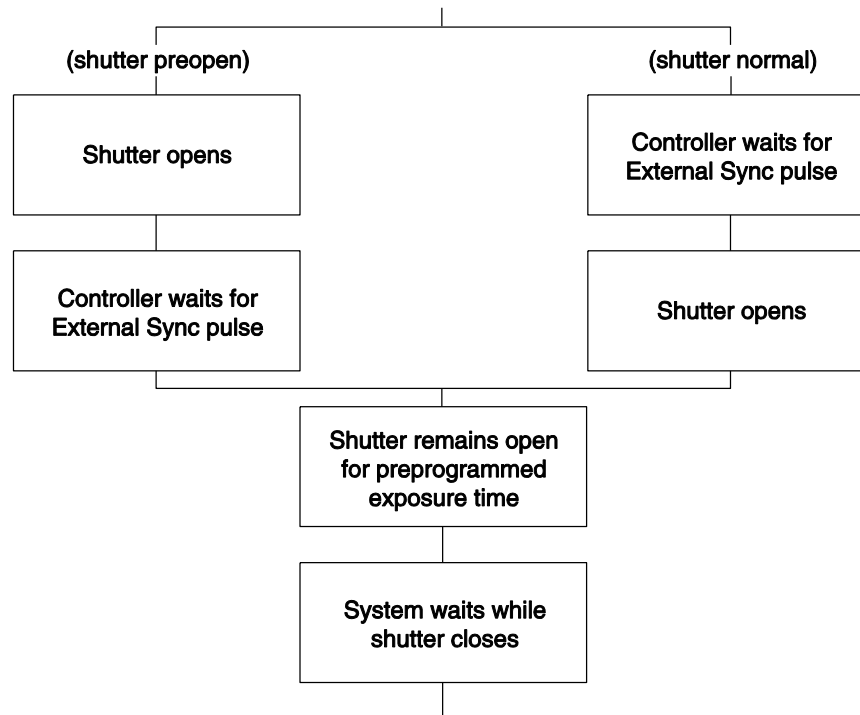
Figure 26. Flowchart of Two External Sync Timing Options

The PreOpen mode is useful in cases where an External Sync pulse cannot be provided 5-28 ms 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 at the end of the readout, the hardware will interpret this as a second sync pulse, and so on.
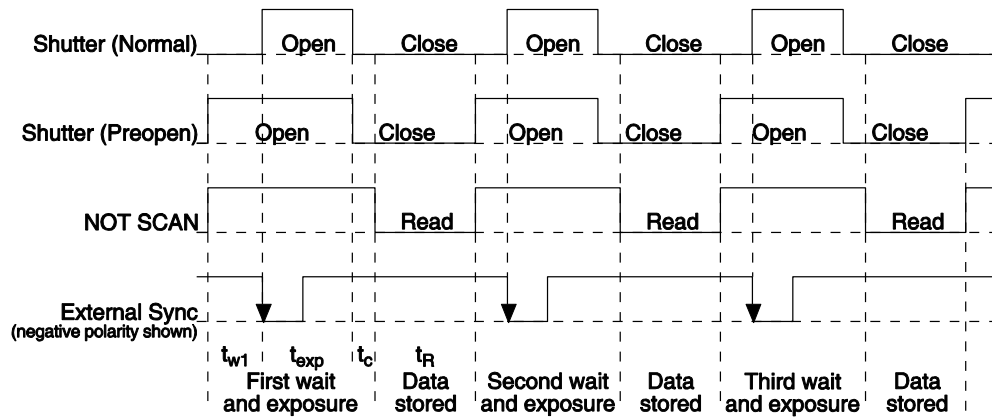
Figure 27. Timing Diagram for External Sync Mode

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 is received.
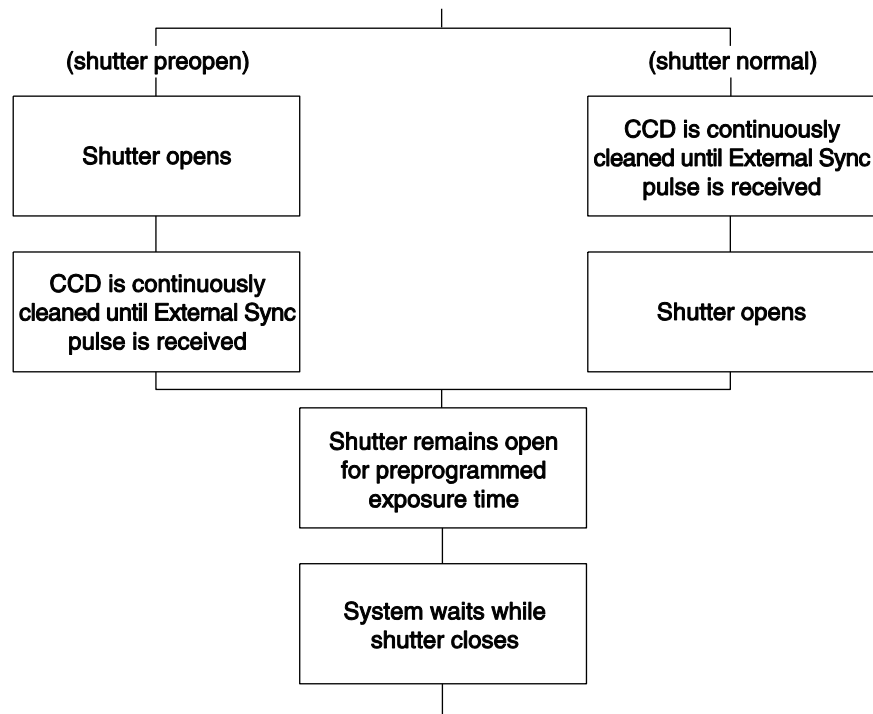
Figure 28. Continuous Cleans Flowchart

Once the External Sync pulse is received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins. With Normal Shutter 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 is received the shutter remains open for the set exposure time, then closes. If the vertical rows are shifted midway when the External Sync pulse arrives, the pulse is saved until the row shifting is completed, to prevent the CCD from getting "out of step." As expected, the

response latency is on the order of one vertical shift time, from 1-30 μsec depending on the array. This latency does not prevent the incoming signal from being detected, since photo generated electrons are still collected over the entire active area. However, if the signal arrival is coincident with the vertical shifting, image smearing of up to one pixel is possible. The amount of smearing is a function of the signal duration compared to the single vertical shift time.

Note: If EXT SYNC is still active at the end of the readout, the hardware will interpret this as a second sync pulse, and so on.
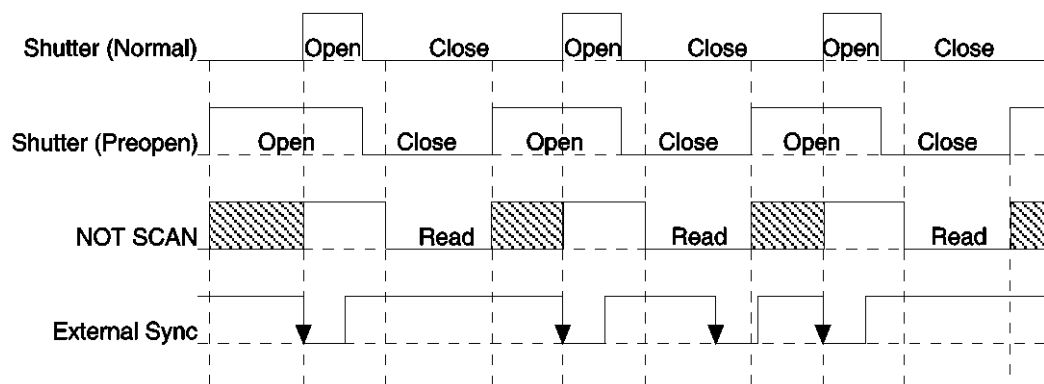
Figure 29. Continuous Cleans Timing Diagram

Fast and Safe Speed Modes

The WinSpec/32 Experiment Setup **Timing** tab page allows the user to choose **Fast** or **Safe Mode**. Figure 23 is a flow chart comparing the two modes. In Fast Mode operation, the Spec-10 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 Spec-10 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 Spec-10 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 video monitor connected to the VIDEO output will always display the current image.* 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 with external devices such as external shutters and filter wheels. As seen in Figure 23, 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 Spec-10, instructing it to stop acquisition. Once that frame is completely processed and displayed, another Start Acquisition command is sent from the computer to the Spec-10, 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 Spec-10 is disabled for a short time after each frame.

Kinetics Mode

> *Kinetics operation requires that the Kinetics option has been installed in the Controller. If the communication protocol is USB 2.0, kinetics operation is supported by WinSpec Version 2.5.18.1 or higher.*

Introduction

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

Note: 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 that uses a 4 × 6 CCD with 2/3 of the array 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 30.
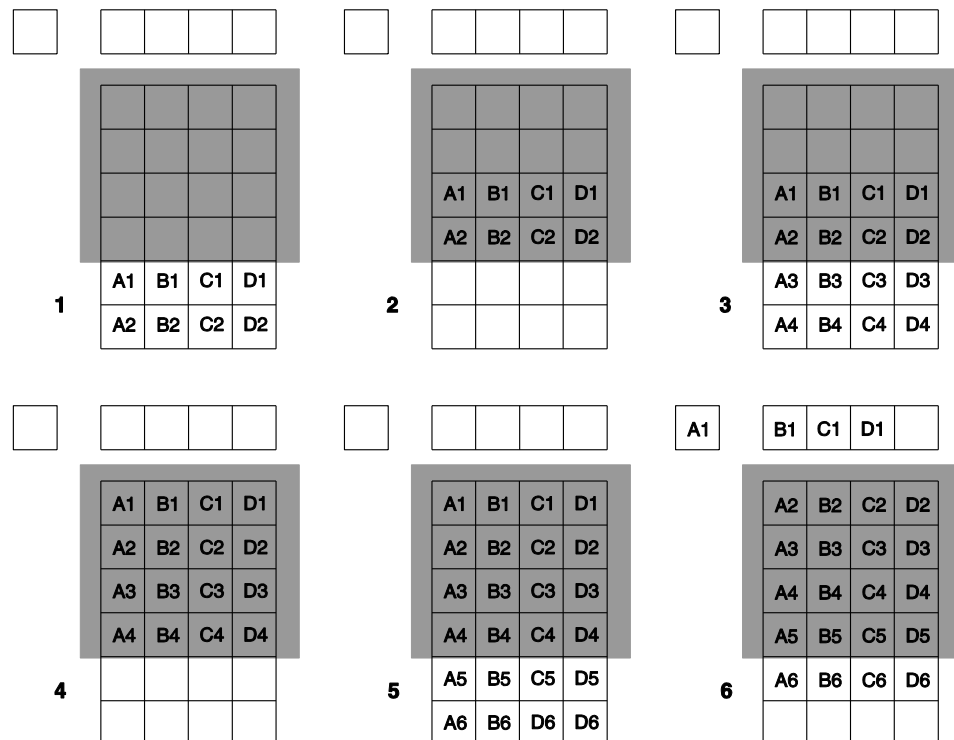
Figure 30. Kinetics Readout

Timing Modes

Kinetics mode operates with three timing modes: Free Run, Single Trigger, and Multiple Trigger.
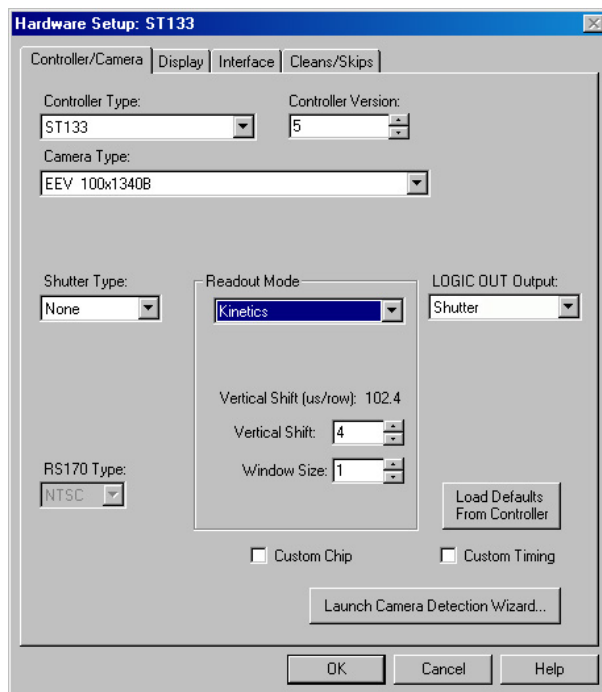
Figure 31. Hardware Setup dialog box   *Figure 32. Experiment Setup dialog box*
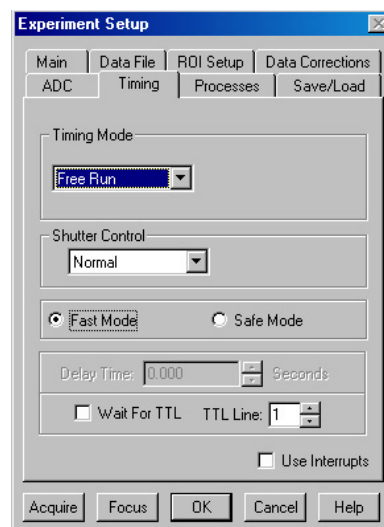
Free Run

In the Free Run Kinetics mode, the controller takes a series of images, each with the Exposure time set through the software (in WinSpec32, 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 μsec/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 30, 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 μsec /row, the Shift time will be 3.2 μsec per frame.

Integrate signals (SHUTTER) or Readout signals (NOT SCAN) are provided at the SCAN BNC for timing measurements.
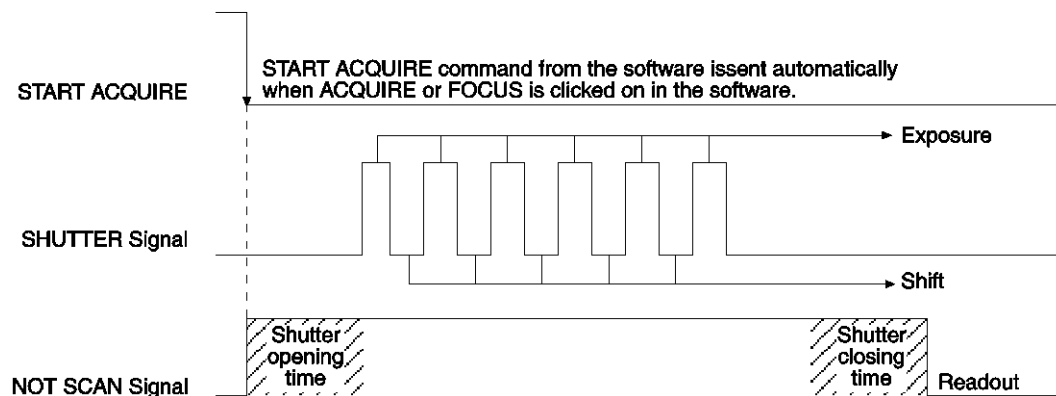
Figure 33. Free Run Timing Diagram

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 ST133). 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 34, where a single External trigger pulse is used to collect a burst of 6 frames.
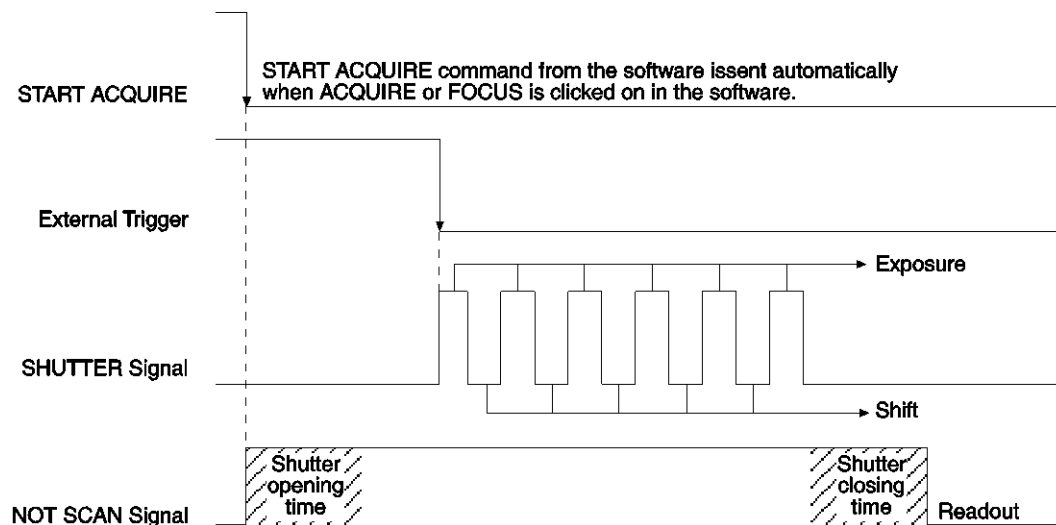
Figure 34. Single Trigger Timing Diagram

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 35, where a series of 6 frames is collected with 6 External Sync pulses.
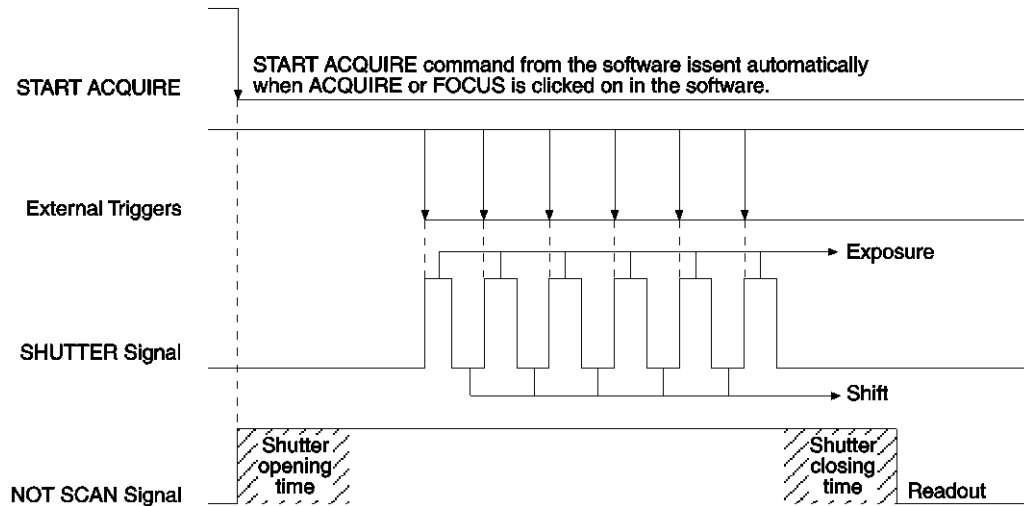
Figure 35. Multiple Trigger Timing Diagram

TTL Control

Fully supported by 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 Instrument's WinSpec/32 software package incorporates WinX32 Automation,
a programming language that can be used to automate performing 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. 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 36 illustrates the connector and Table 10 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 9 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 9. 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 WinSpec/32. Typically, a program monitoring the experiment sets one or more of the TTL Outputs. Apparatus external to the ST-133 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.

TTL IN/OUT

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	(future use)	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		

Figure 36. TTL IN/OUT connector

Table 10. TTL In/Out connector pinout

TTL Diagnostics Screen

Note that WinSpec/32 provides a TTL Diagnostics screen (located in WinSpec/32 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 at the ST-133. The hardware at the other end of the cable will depend entirely on your requirements. If the individual connections are made using coaxial cable for maximum noise
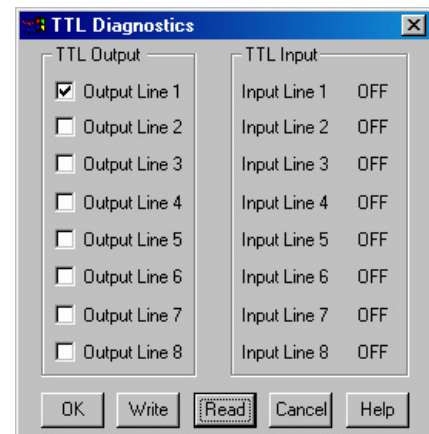
Figure 37. TTL Diagnostics dialog box

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 electronics 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.

- Shielded Metalized hood (Radio Shack part no 276-1536A).

- BNC connector(s) type UG-88 Male BNC connector (Radio Shack part no 278-103).

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 10, 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 controller.

8. To check the cable, start WinSpec/32 and open the TTL Diagnostics screen (located in WinSpec 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.

Chapter 7

Troubleshooting

WARNING!   Do not attach or remove any cables while the Spec-10 system is powered on.

Introduction

The following issues have corresponding troubleshooting sections in this chapter.

Baseline Signal Suddenly Changes

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 (also remove liquid nitrogen from the detector, if appropriate) and have the detector repumped before resuming normal operation. *Contact the factory Customer Support Dept. for further instructions. See page 146 for contact information.*

Camera Stops Working

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

- Turn off all AC power.
- Verify that all cables are securely fastened and that all locking screws are in place and all slide latches are in the latched position. For instructions on operating the slide latch locking mechanism, see *"Securing the Detector-Controller Cable Slide Latch"*, page 91.
- Check for a burned-out fuse in the Controller power module. For information about changing a fuse, see *"Changing the ST-133 Line Voltage and Fuses"* on page 79.
- Correct any apparent problems and turn the system on.
- If the system still does not respond, contact Customer Support.

Camera1 (or similar name) on Hardware Setup dialog box
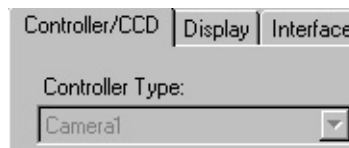
Figure 38. Camera1 in Controller Type (Camera Name) Field

If you see a default name such as Camera1 on the **Setup|Hardware|Controller/CCD** tab page, you may want to change it since this name is not particularly descriptive. 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 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

2.   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

3.   The new camera name will now appear in the **Controller Type** (**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 back of the power 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 detector to be properly protected.

To Change Voltage and Fuse Configuration:

WARNING!   Before opening the power module, turn the Controller OFF and unplug the powercord.

1.   As shown in Figure 39, place the flat side of a flat bladed screwdriver parallel to the back of the Controller and behind the small tab at the top of the power module, and twist the screwdriver slowly but firmly to pop the module open.

2.   To change the voltage setting, roll the selector drum until the setting that is closest to the actual line voltage is facing outwards.

Figure 39. Power Input Module

Figure 40. Fuse Holder

3.   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 and gently pry the assembly out.

4.   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.

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 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 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 WinSpec/32 **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 software 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 WinSpec/32 and turn the Controller OFF. Follow the interface card installation instructions in Chapter 4 and cable the interface card to the SERIAL COM port on the rear of the Controller. Then do a "Custom" installation of WinSpec/32 with the appropriate interface component selected: "PCI Interface". Be sure to deselect any interface component that does not apply to your system.

• If the interface card is installed in the computer and is cabled to the SERIAL COM port on the rear of the Controller, close WinSpec/32 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 WinSpec/32 has been installed, close WinSpec/32 and do a "Custom" installation of WinSpec/32 with the appropriate interface component selected: "PCI Interface". Be sure to deselect any interface component that does not apply to your system.

Cooling Troubleshooting

Temperature Lock cannot be Achieved or Maintained.
Possible causes could include:

• The vacuum has deteriorated and needs to be refreshed.

• The connectors of the cable that interconnects the controller and the detector need to be secured.

• The target array temperature is not appropriate for your particular detector and CCD array.

• For a TE-cooled detector, the detector'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 or warmer than the specified limit. TE-cooled detectors are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, detector operation is restored automatically in about ten minutes. Although the

thermo-protection switch will protect the detector, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

Detector loses Temperature Lock

The internal temperature of the detector is too high. This might occur if the operating environment is particularly warm or if you are attempting 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, detector operation is restored in about ten minutes. Although the thermal overload switch will protect the detector, 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 detector is in thermal overload (thermal switch is in the cut-out state) is -100° C.*

Note: If the **Detector Temperature** dialog box is open, the following message will be displayed in the box when thermal overload is detected: *"Detector Overheated! Consult operations manual or contact PI Customer Support if problem persists."*

Gradual Deterioration of Cooling Capability

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

Vacuum deterioration occurs primarily as a result of outgassing of components in the vacuum chamber. Because outgassing normally diminishes with time, the rate of vacuum deterioration in new detectors will be faster than in old ones. When the detector no longer maintains an acceptable cold temperature, *contact the factory Customer Support Dept. to make arrangements for returning the detector to have the vacuum restored. See page 146 for contact information.*

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

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 WinSpec/32.

Data Overrun Due to Hardware Conflict message
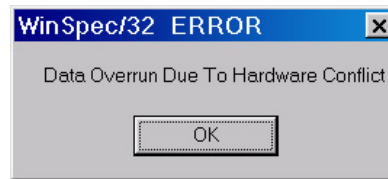
Figure 41. Data Overrun Due to Hardware Conflict dialog box

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 WinSpec.

4. Reboot your computer.

5. Restart WinSpec 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 WinSpec/32.

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 USB 2.0 Driver:"*, page 31.

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) PCI card. If this is not the case and data overruns continue to occur, contact Customer Support (see page 146 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 Wizard will only present the choice "Demo" in the Interface dialog box (Figure 42). 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.
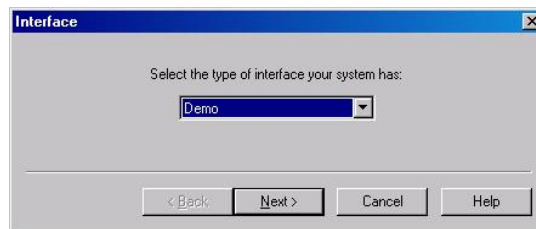
Figure 42. Hardware Wizard: Interface dialog box

At this point, you will need to exit WinSpec 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 Wizard when you are setting up WinSpec/32 with USB for the first time:

1. If you have not already done so, close WinSpec/32.

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 WinSpec.

4. When the RSConfig dialog box (Figure 43) 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.
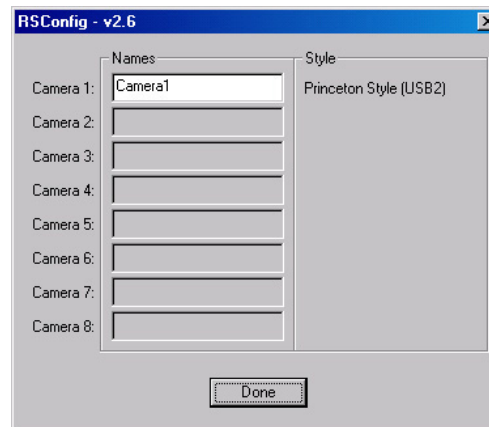
Figure 43. RSConfig dialog box

5. You should now be able to open WinSpec and, from **Setup|Hardware…,** run the Hardware Wizard.

6. When the PVCAM dialog box (Figure 44) 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 44. 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 Wizard when you are setting up WinSpec/32 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.
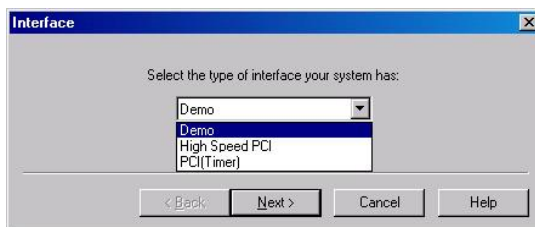
Figure 45. Hardware Wizard: Interface dialog box

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

1. If you have not already done so, close WinSpec/32.

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 WinSpec.

4. When the RSConfig dialog box (Figure 46) 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.
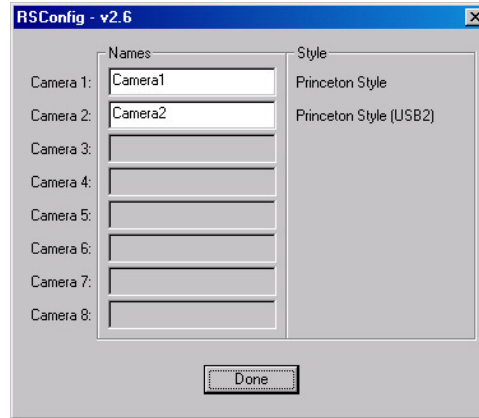
Figure 46. RSConfig dialog box: Two Camera Styles

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 WinSpec/32.

7. Run the Hardware Wizard.

8. When the PVCAM dialog box (Figure 47) 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 47. 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 WinSpec/32 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 WinSpec, verify that the ST-133 is connected to the host computer, turn on the ST-133, and reopen WinSpec. 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 48), you will have to edit the PVCAM.INI file.
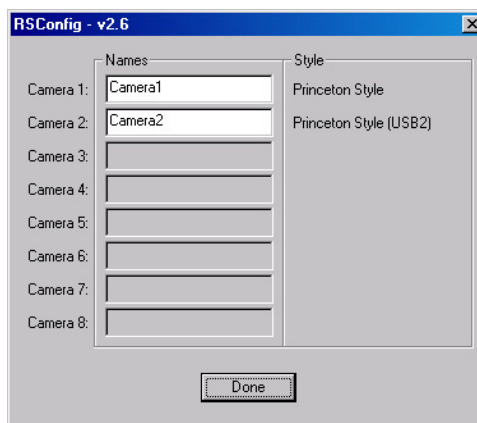
Figure 48. RSConfig dialog box: Two Camera Styles

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 WinSpec/32. 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 WinSpec/32 and began running the Hardware Wizard.
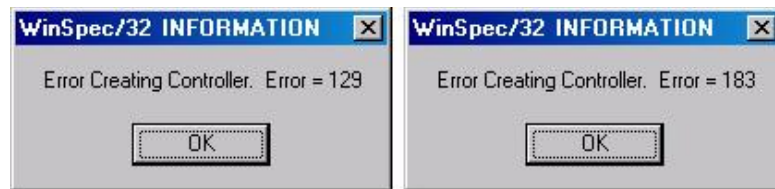
Figure 49. Error Creating Controller dialog box

Error 129: Indicates that the problem is with the PVCAM.INI file. Close WinSpec/32, run RSConfig, make sure the ST-133 is on, reopen WinSpec, and begin running the Hardware Wizard.

Error 183: Indicates that the ST-133 is off. If you are running the Hardware 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 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 card 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.

Diagnostics 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.

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 (WinSpec/32). 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.

No CCD Named in the Hardware Wizard:CCD dialog (Versions 2.5.19.0 and Earlier)
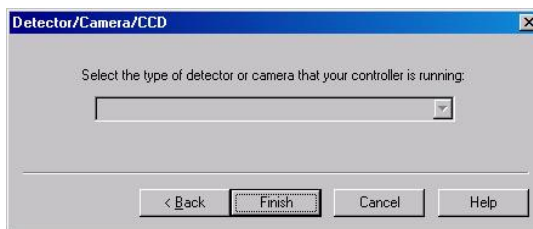
Figure 50. Hardware Wizard: Detector/Camera/CCD dialog box

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 50) 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 WinSpec/32.

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.

Program Error message

Figure 51. 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 WinSpec.

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 WinSpec.

6. Reboot your computer.

7. Restart WinSpec and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Removing/Installing a Plug-In 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. The third slot, however, is covered with a blank panel unless a PTG module has been installed in the ST-133.

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.

WARNINGS!

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.
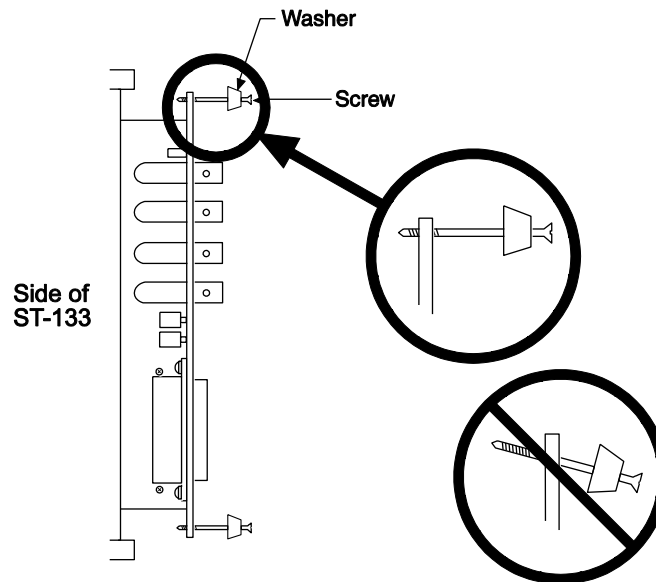
Figure 52. Module Installation

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 52.* 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 Spec-10 (the detector 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.
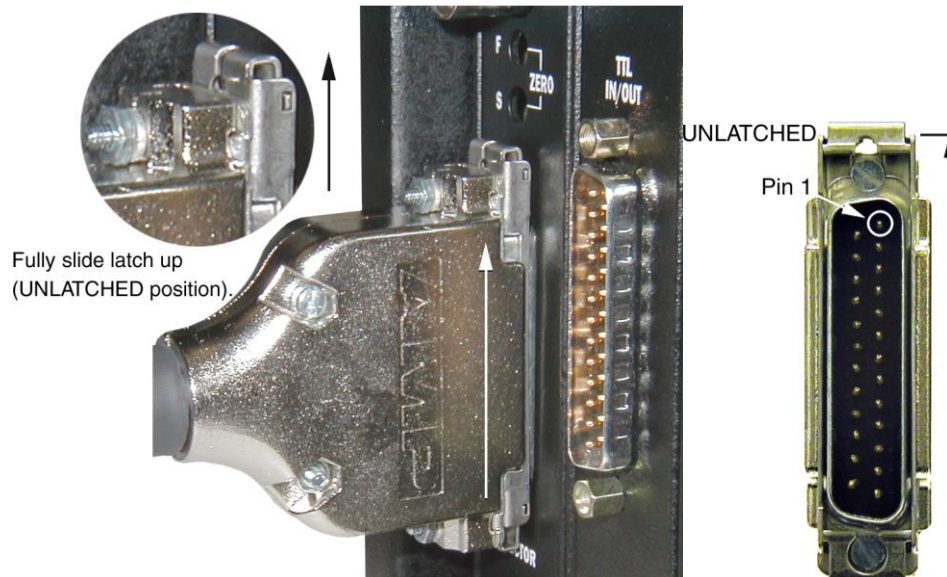
2. Slide the latch down. You may hear a click when the latch locks.
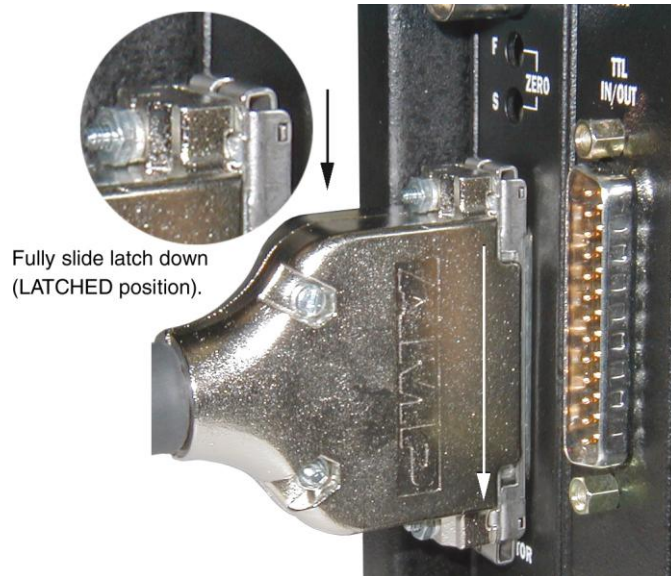
3. Verify that the connector is fully secured.

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 53. 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 Malfunctions

- Verify that the correct shutter setting has been selected on the rear of the Controller. Refer to Table 4 on page 36.

- If you are using a 25 mm remote-mounted shutter and it suddenly stops running, its built-in thermal interlock may have been triggered. Stop the experiment and wait. The shutter should resume functioning when it has cooled down sufficiently, typically within an hour. Avoid repeating the conditions (such as high repetition rate) that lead to the shutter overheating, or take breaks between data collections.

- If the shutter no longer operates at all, sticks open or closed causing overexposed or smeared images, or a shutter leaf has broken and no longer actuates, contact the factory to arrange for a shutter-replacement repair.

Vignetting

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

- Condensation of water on the edges of the array window has occurred. This should not happen unless the cooling/pumping instructions, previously mentioned, were not followed or if the Dewar has developed a vacuum leak (a rare situation).

- The arrays are held with a special mask that has been designed to minimize reflection and stray light. These masks were designed to allow light rays to enter through the Dewar window even at very wide angles ($\geq$ f/1.5). If vignetting is observed, it is possible that your experiment exceeds these angular constraints. Princeton Instruments measures the array response with a collimated uniform light source to prevent such false bias results.

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Appendix A

Specifications

Computer

Type: Any Pentium (or better) PC having a free slot for the Serial Buffer card (PCI is standard; other types may be available).

Memory (RAM): Minimum of 32 Mbytes; possibly more depending on experiment design and size of CCD Array.

Operating System: Windows 95, NT or later for WinSpec/32.

Interface: Princeton Instruments (RSPI) PCI High-Speed Serial I/O card is standard. Other types may be available. Contact factory for information.

Controller

Controller Type: ST-133

Inputs:

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. Synchronization and Trigger Modes are discussed in Chapter 6.

Outputs:

VIDEO or **AUX**

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.

Aux: Reserved for future use.

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.

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.

TTL I/O: 8 TTL Inputs and 8 TTL Outputs are provided for control via the TTL connector. Refer to *"TTL Control"*, page 72 for more information.
    TTL Input: external sync

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

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

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.

Linearity: better than 1%.

Readout noise: 1-1.2 counts RMS on standard controllers.

Exposure (integration) Time

5 ms (shutter) to 2.3 hours (full frame)

Shutter Compensation Time

The following numbers apply for a 1 MHz ST-133.

Shutter	Exposure
25 mm or smaller (small Princeton Instruments supplied internal shutter)	8.0 ms
35 mm or larger (large Princeton Instruments supplied internal shutter)	28.0 ms
25 mm or smaller (Princeton Instruments supplied external shutter)	8.0 ms
NONE	200 ns

Miscellaneous

Dimensions: See Appendix B.

Controller Weight:
ST-133A: 13 lb (5.9 kg)
ST-133B: 12.5 lb (5.7 kg)

Power Requirements: 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.

Environmental Requirements:

Storage temperature: -20° C to 55° C;

Operating temperature: 5℃ to +30℃; For NTE/NTE 2 Detectors, the operating temperature range over which specifications can be met is 18° C to 23° C

Relative humidity: <50% noncondensing.

Detector

Temperature Control

Setting Mechanism: Temperature is set by the application software.

Display: The actual temperature can be displayed at the computer by the application software.

Stability: ±0.05°C over entire temperature range

Cooling Methods:

LN Dewar	**TE-Liquid Only**
TE-Air Assist	**TE-Liquid Assist**

Temperature Range: A function of cooling method and detector type.

LN-cooled: typically -70° C to -120° C

TE-cooled: several of the Spec-10 detectors cool typically below -45° C with forced air; below -50° C with optional liquid-assist or with liquid-cooling option and chiller/recirculator.

Deep TE-cooled: +20° C to below -70° C with forced air; +20° C to -90° C with liquid-cooling option and chiller/recirculator.

XP TE-cooled: +20° C to -80° C with forced air.

XTE-cooled: +20° C to -100° C (Spec-10:100 series) or +20° to C -90° C (Spec-10:400 series) with forced air.

Time to Lock: A function of detector type; ~ 10 minutes for TE, ~30 minutes for deep TE, XP, and XTE, and ~ 2 hours for cryogenic.

Fan Capacity: 30 cfm at full power.

Circulating Coolant: Spec-10 detectors with liquid-assisted or liquid-only cooling require circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation. All hose connections should be secured with good quality hose clamps.

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

Fluid Pressure: 25 psig (maximum).

Inlet/Outlet Port Locations: Two quick-disconnect coolant ports are supplied with a liquid-assist system and are mounted at the sides of the detector. Either port can be the inlet or the outlet for liquid-assist systems. For liquid-cooled systems, the correct port must be used for the inlet. Use 1/4" thin-wall plastic tubing or 3/8" I.D. thick-wall PVC tubing, depending on the Spec-10 model.

CCD Arrays

A variety of front- illuminated, back-illuminated, and eXcelon-enabled back-illuminated CCD arrays are available for 27-mm spectral coverage and for near-IR. Contact the factory for up-to-date information on available chips and chip performance specifications.

Window

SI-UV fused silica quartz. Anti-reflection coatings for various wavelength ranges are available.

Mechanical Focal Depth

LN-cooled: Shuttered 0.894"
Non-shuttered 0.549"
TE-cooled: 0.593" for NTE and XP
0.599" for NTE 2 and XTE

External Shutter (optional)

0.9 in (23 mm) aperture, 8 ms open time, 8 ms close time

Internal Detector Shutter (optional for LN only)

1.59 in (40 mm) aperture, 28 ms open time, 28 ms close time.

Environmental Requirements

Storage temperature: $<55°C$
Operating environment: $5°C < T < 30°C$
Relative humidity: $\leq 50\%$; non-condensing

Outline Drawings

Liquid Nitrogen-Cooled Detector
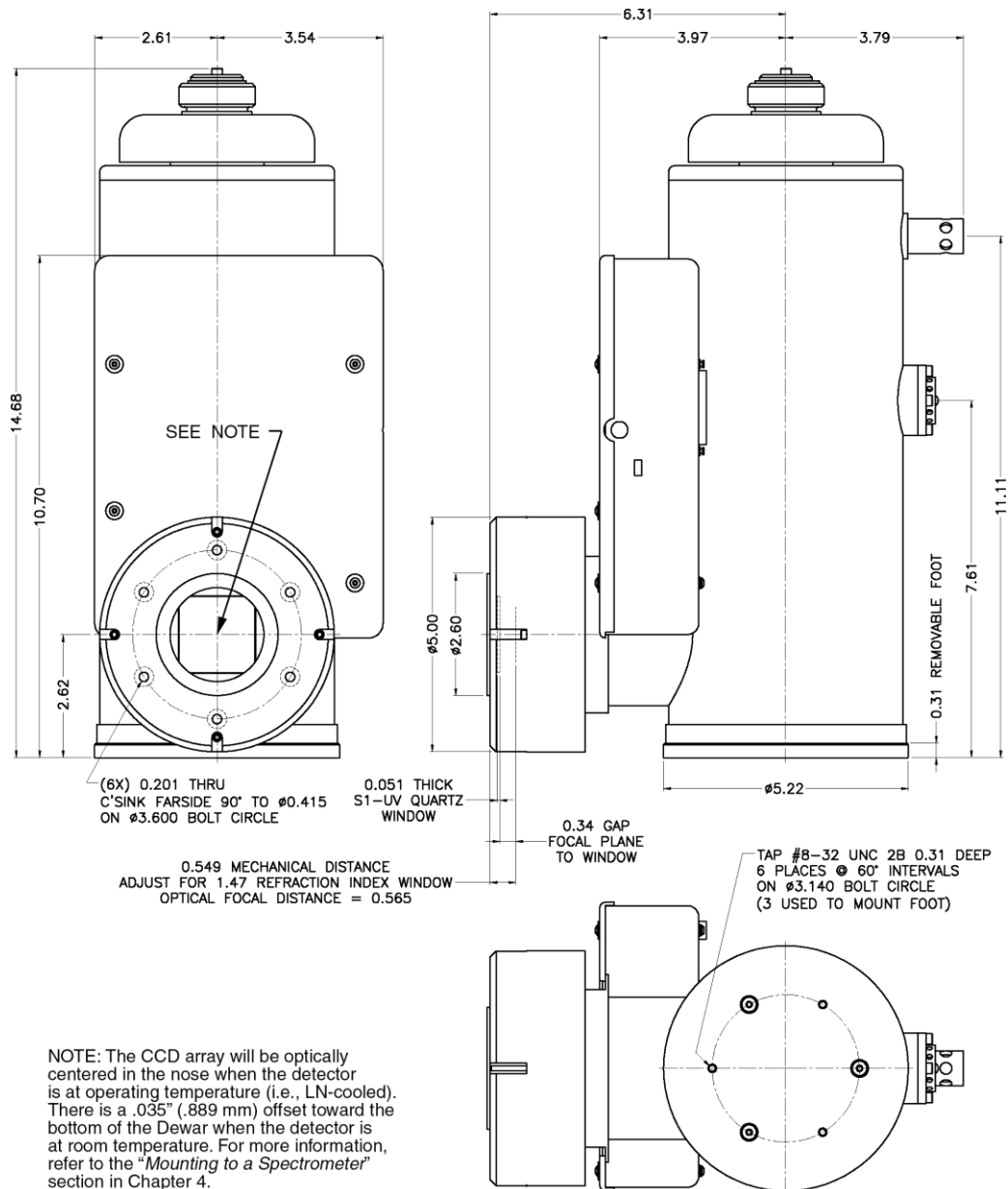
Figure 54. Side-On Dewar, Non-Shuttered: New Design
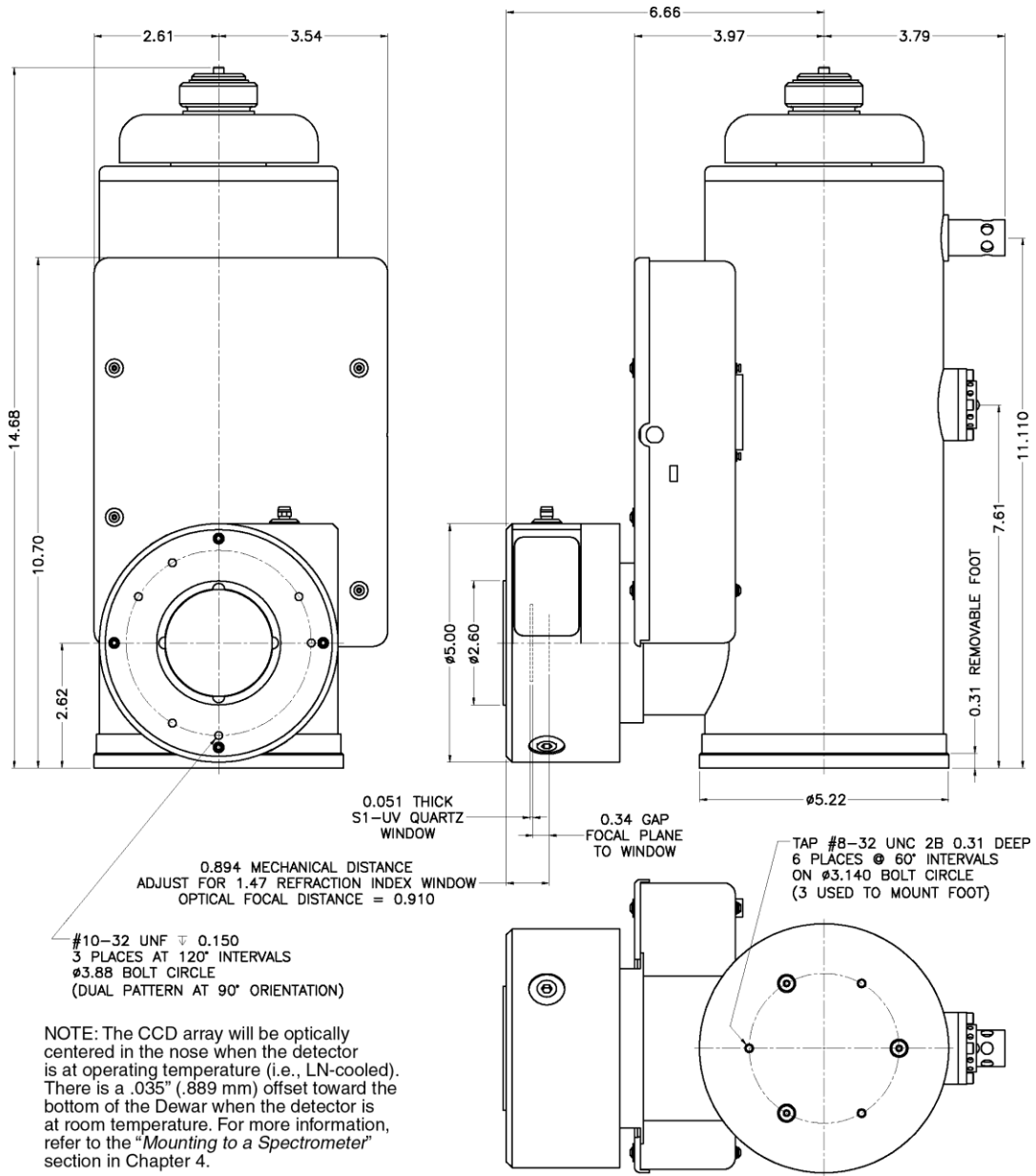
Figure 55. Side-On Dewar, Shuttered: New Design
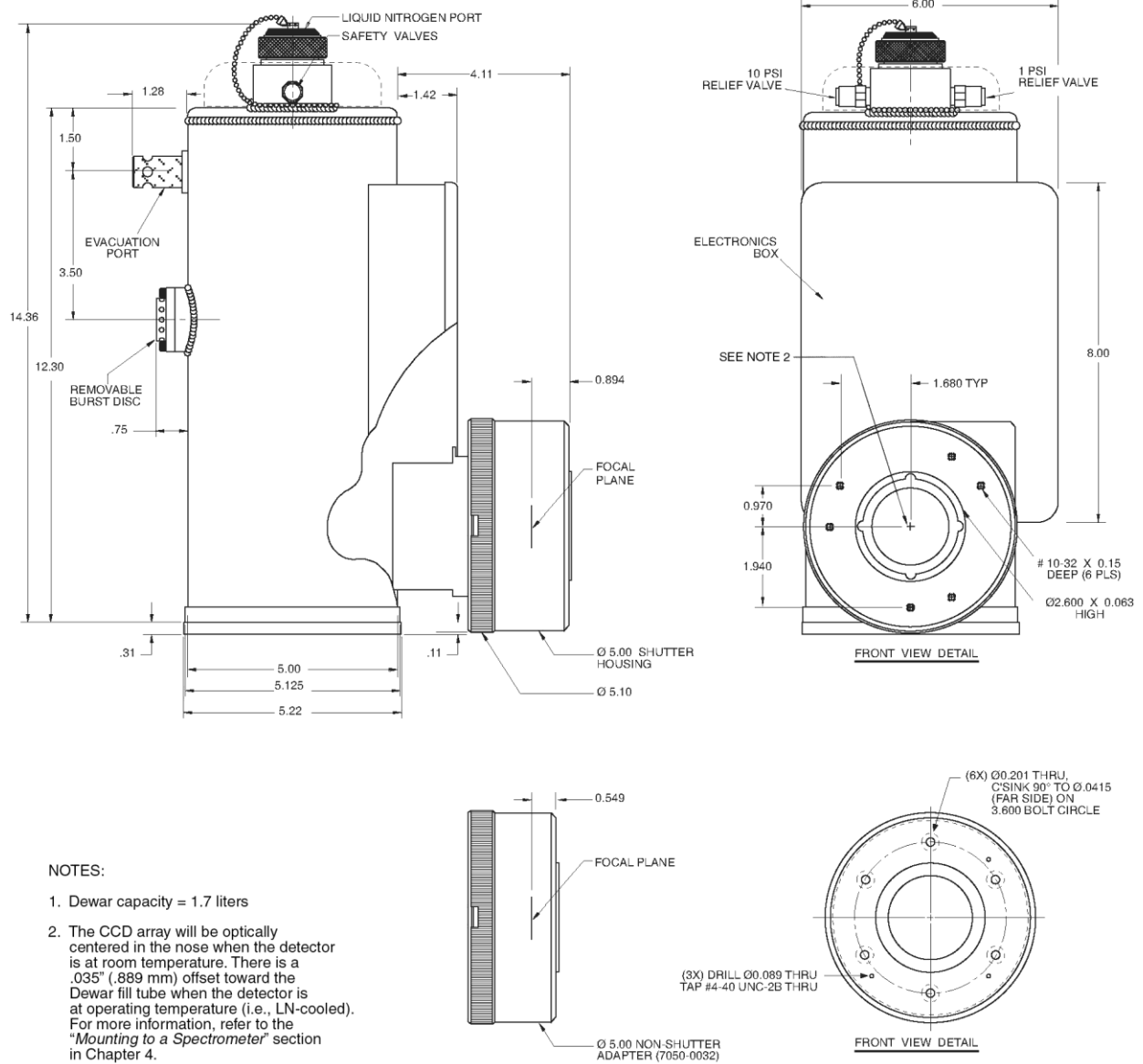
Figure 56. Side-On Dewar: Old Design
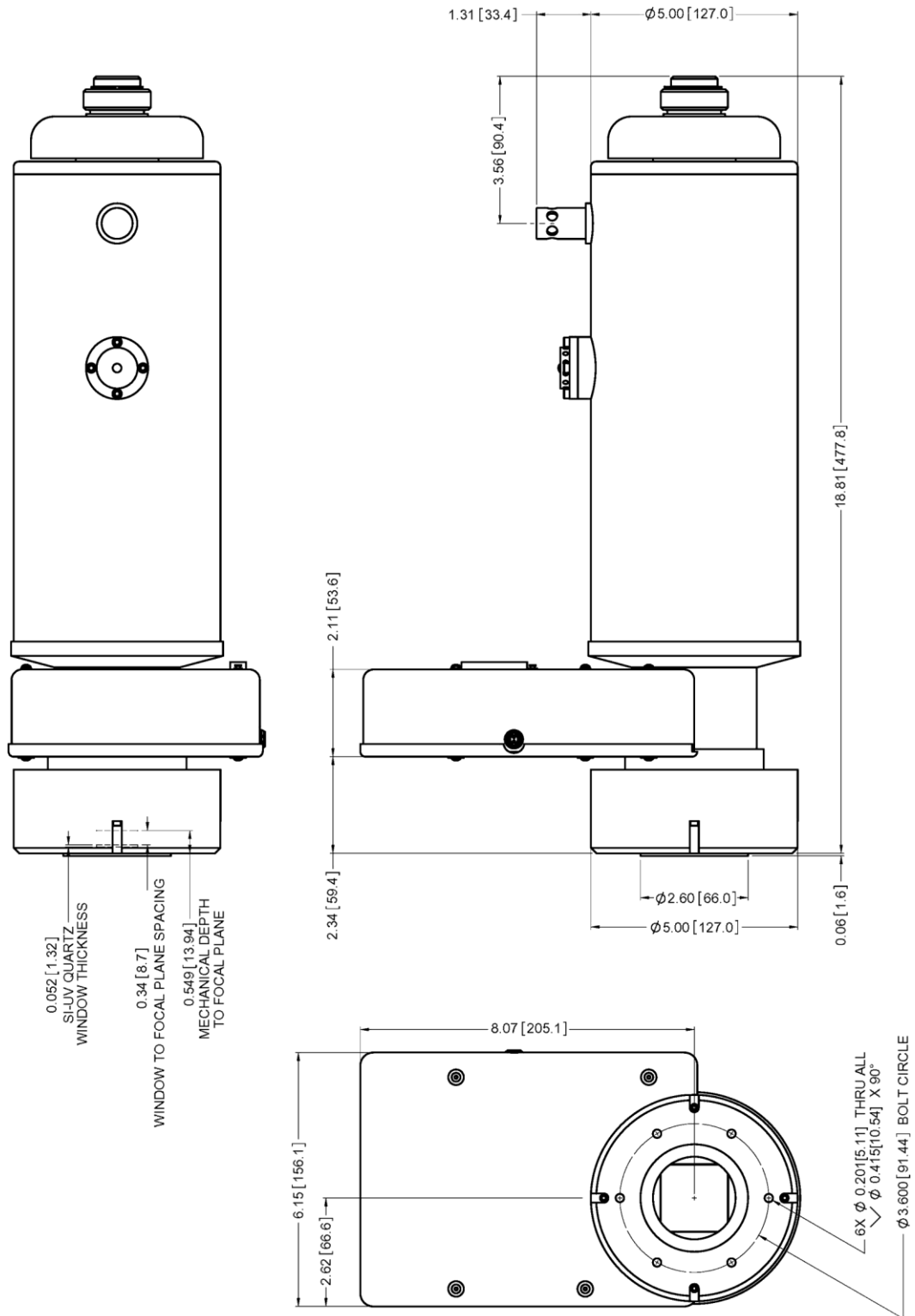
Figure 57. End-On Dewar, Non-Shuttered: New Design
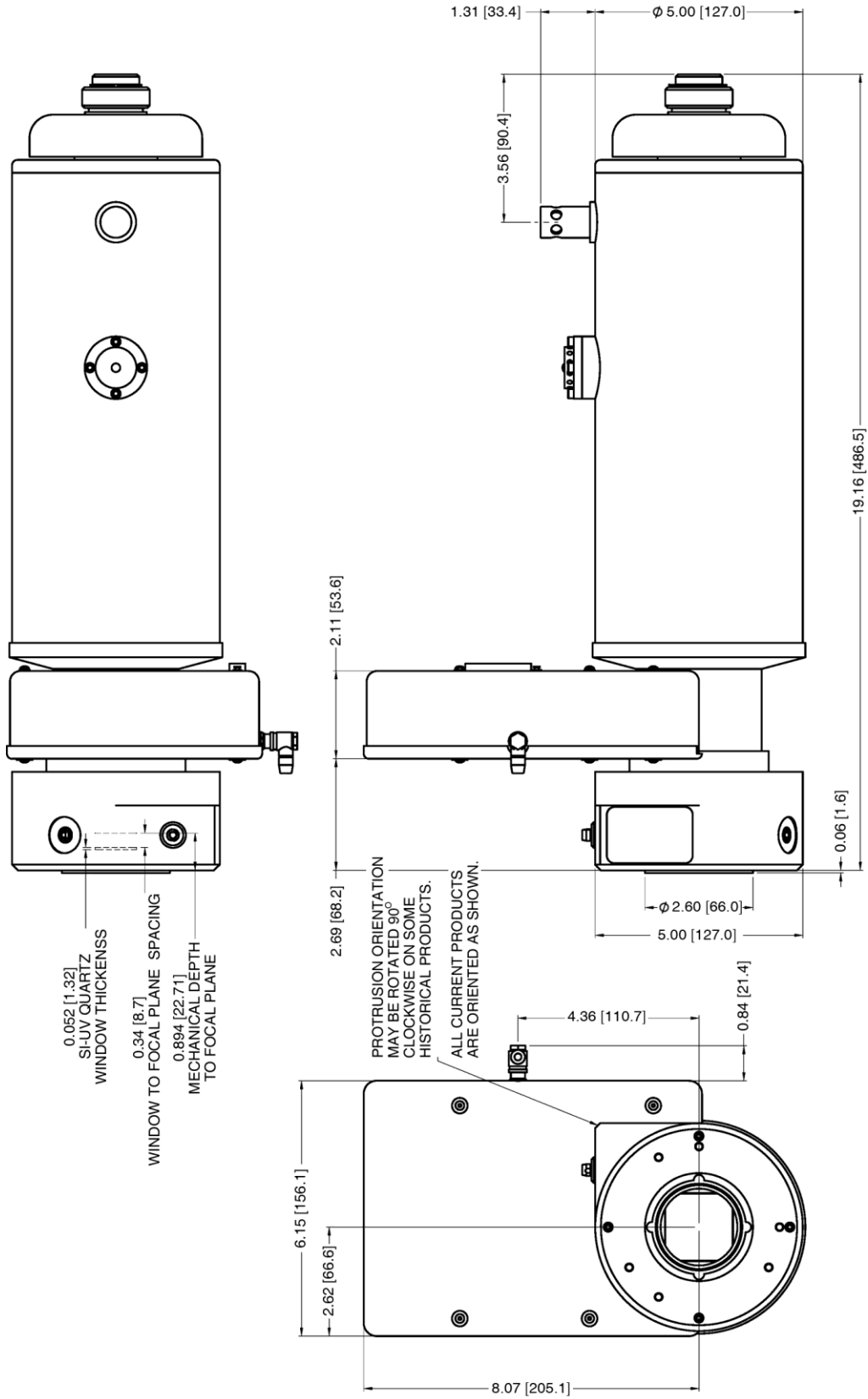
Figure 58. End-On Dewar, Shuttered: New Design
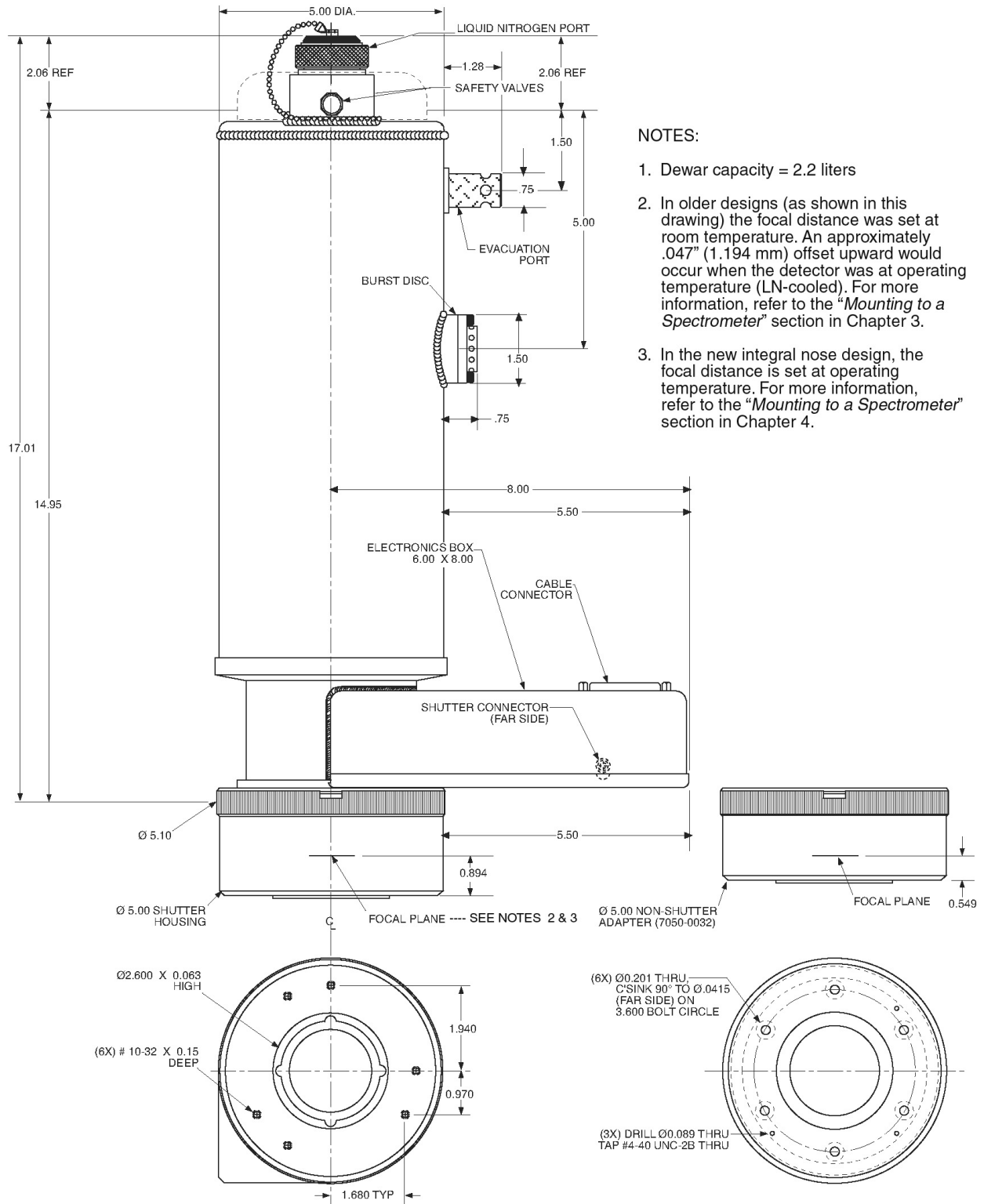
NOTES:

1. Dewar capacity = 2.2 liters

2. In older designs (as shown in this drawing) the focal distance was set at room temperature. An approximately .047" (1.194 mm) offset upward would occur when the detector was at operating temperature (LN-cooled). For more information, refer to the "*Mounting to a Spectrometer*" section in Chapter 3.

3. In the new integral nose design, the focal distance is set at operating temperature. For more information, refer to the "*Mounting to a Spectrometer*" section in Chapter 4.

Figure 59. End-On Dewar: Old Design

Thermoelectrically-Cooled Detector
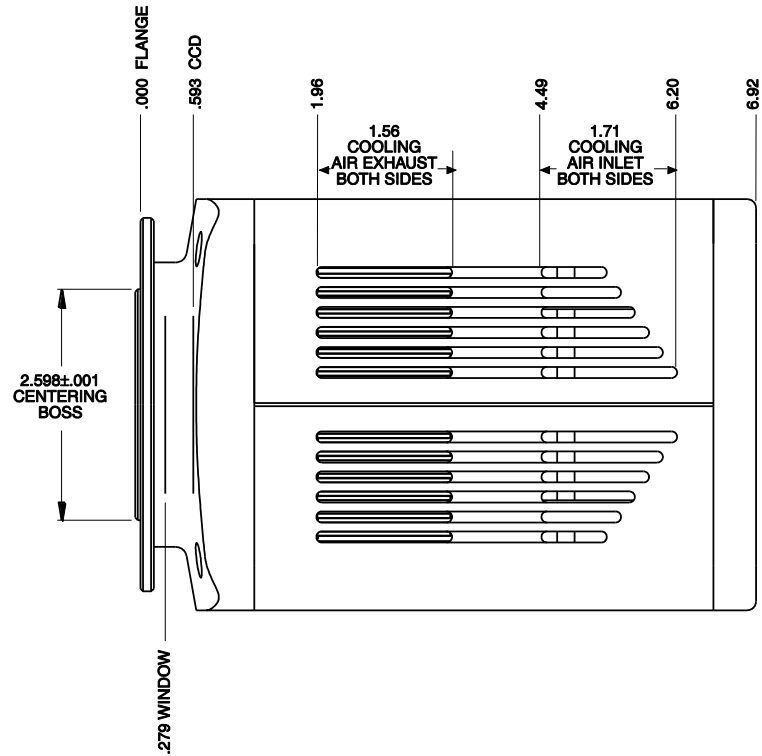
Figure 60. Spectrometer Mount (NTE/XP): Side View
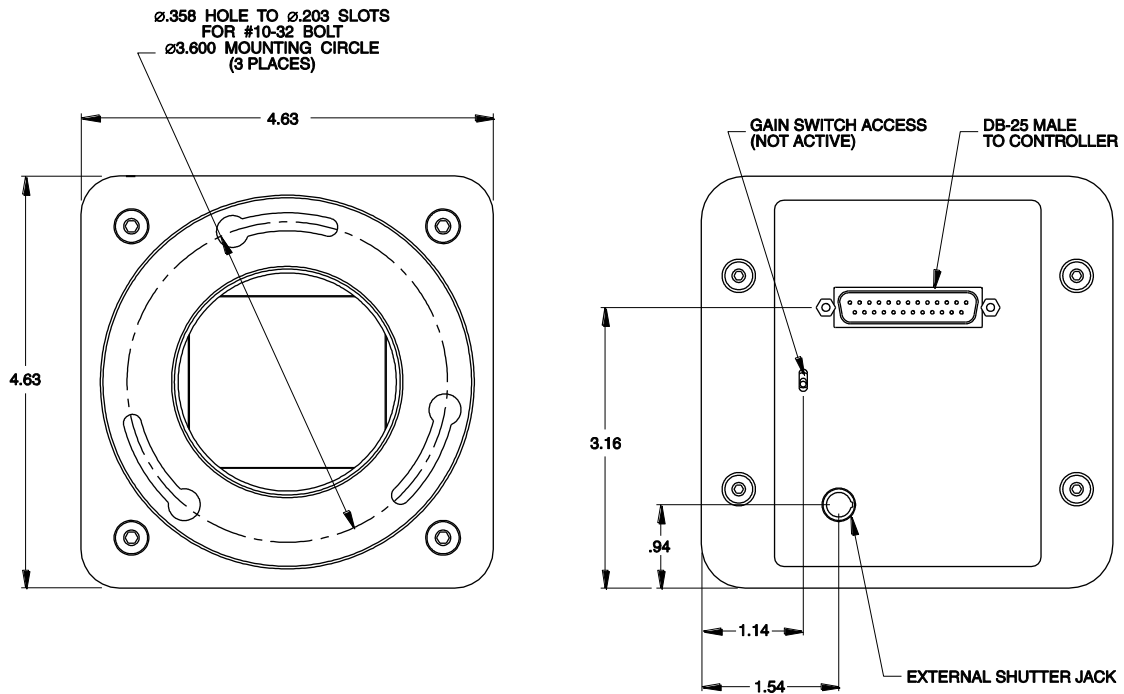
Figure 61. Spectrometer Mount (NTE/XP): Front and Back Views
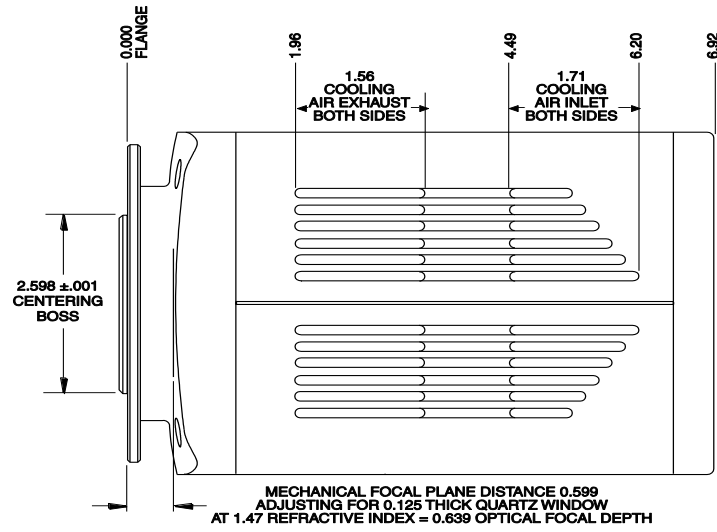
Figure 62. Spectrometer Mount (NTE 2/XTE): Side View
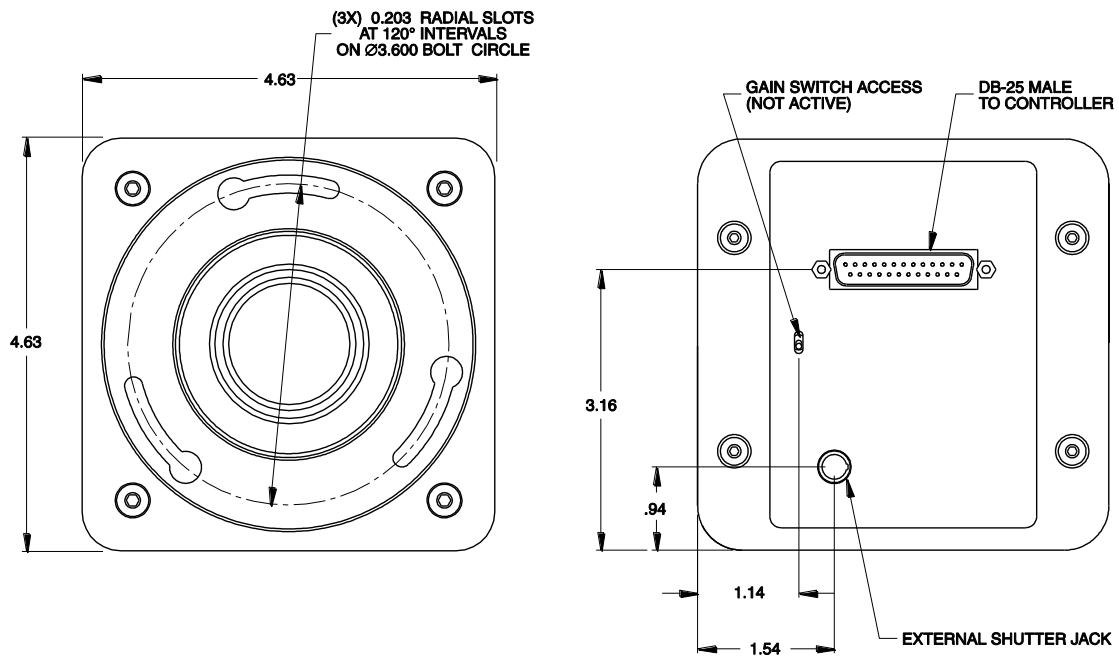
Figure 63. Spectrometer Mount (NTE 2/XTE): Front and Back Views

ST-133B Controller
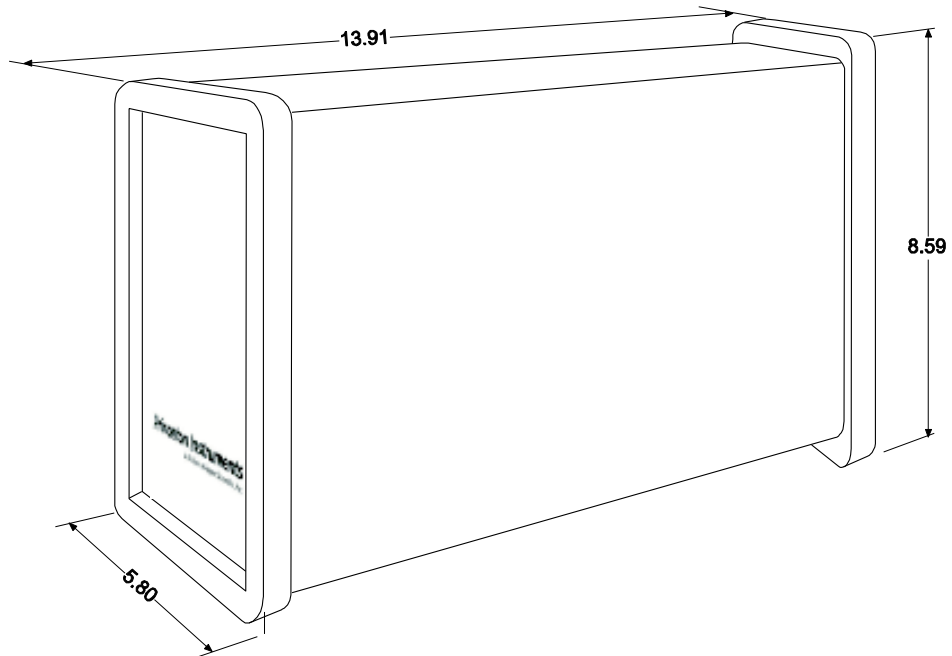
Figure 64. ST-133B Controller Dimensions

ST-133A Controller
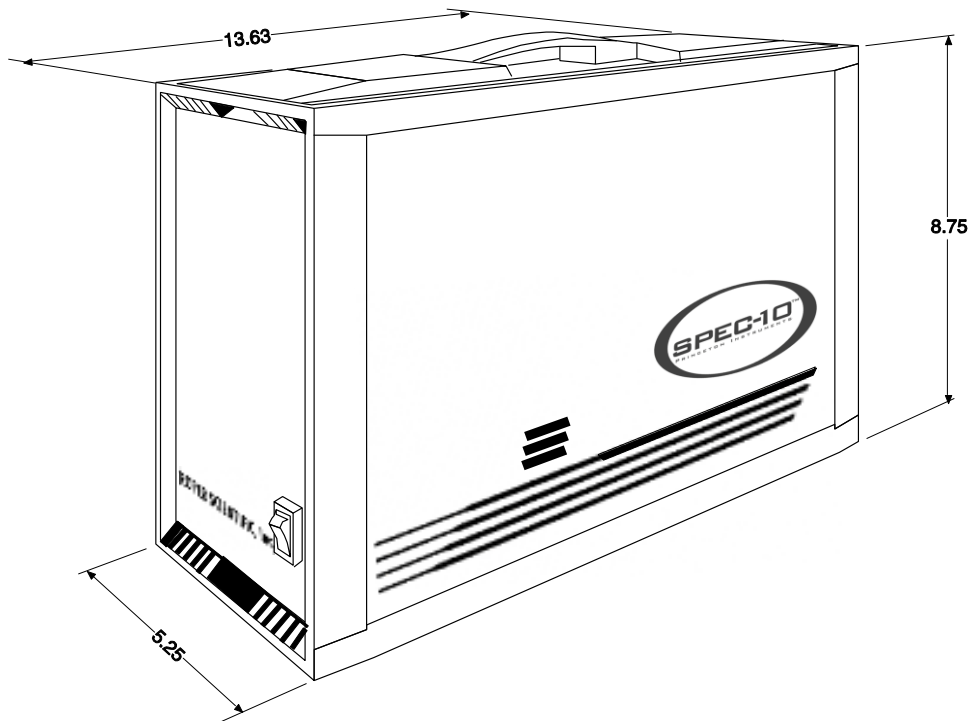
Figure 65. ST-133A Controller Dimensions

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Appendix C
Spectrometer Adapters

Princeton Instruments offers a variety of spectrometer adapters for Spec-10 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		110
Acton	LN without shutter		111
Acton	NTE/NTE 2/XP/XTE		112
Chromex 250 IS	LN with shutter	7050-0089	113
Chromex 250 IS	LN without shutter	7050-0090	114
Chromex 250 IS	NTE/NTE 2/XP/XTE	7050-0090	115
ISA HR 320	LN with shutter	7050-0002	116
ISA HR 320	LN without shutter	7050-0010	117
ISA HR 320	NTE/NTE 2/XP/XTE	7050-0010	118
ISA HR 640	LN without shutter	7050-0034	119
ISA HR 640	NTE/NTE 2/XP/XTE	7050-0034	120
JY TRIAX family	LN without shutter	7050-0082	121
JY TRIAX family	NTE/NTE 2/XP/XTE	7384-0072	122
SPEX 270M	LN with shutter	7050-0042	123
SPEX 270M	LN without shutter	7050-0041	124
SPEX 270M	NTE/NTE 2/XP/XTE	7050-0041	125
SPEX 500M	LN with shutter	7050-0018	126
SPEX 500M	LN without shutter	7050-0038	127
SPEX 500M	NTE/NTE 2/XP/XTE	7050-0038	128
SPEX TripleMate	LN with shutter	7050-0006	129
SPEX TripleMate	LN without shutter	7050-0007	130
SPEX TripleMate	NTE/NTE 2/XP/XTE	7050-0007	131

Acton (LN with shutter)

Adapter (supplied with spectrometer)
Spacer Plate (removed)

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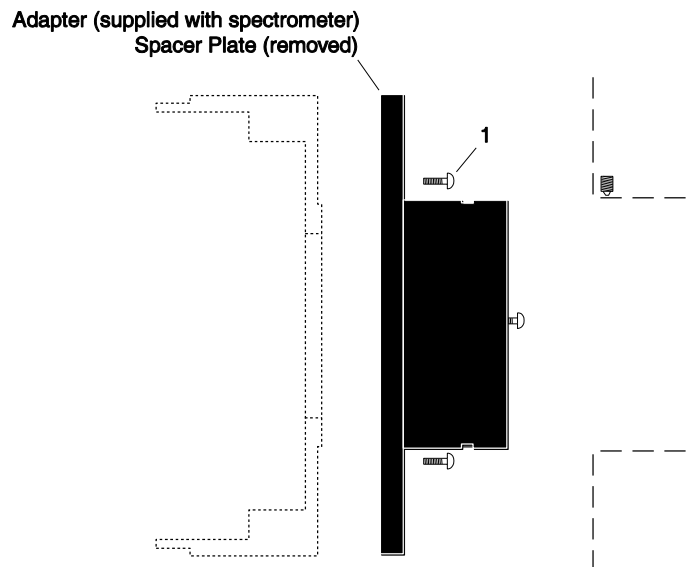
	Qty	P/N	Description
1.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel

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 adapter in the spectrometer and remove the adapter.

3. Remove the spacer plate from the adapter by removing the three (3) socket head screws.

4. Mount the Acton adapter to the face of the detector drum housing (dashed outline in illustration) with the three (3) 1/4" long button head screws.

5. Gently insert the adapter into the spectrometer 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.
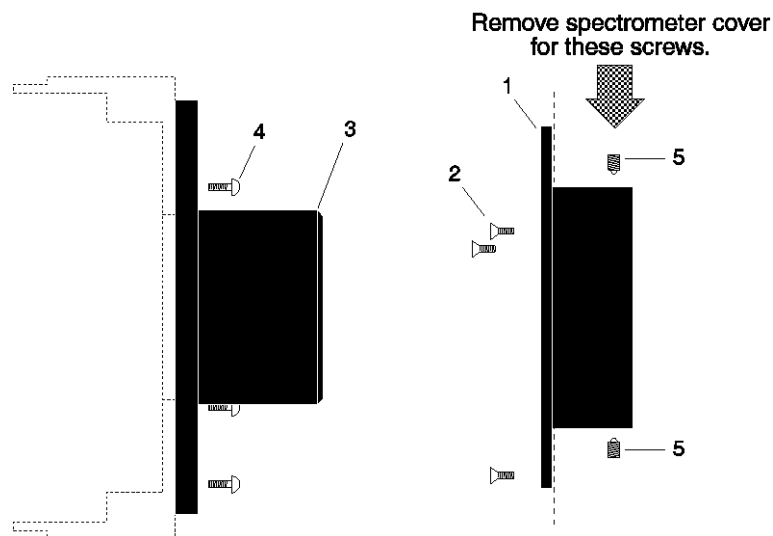
Acton (LN without shutter)

**Adapter and Spacer Plate
(supplied with spectrometer)**

1
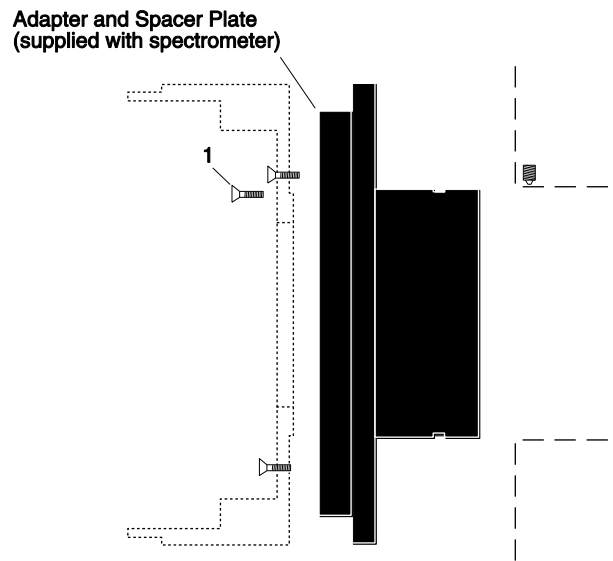
Qty	P/N	Description
1.	3	2826-0251	Screw, 10-32 × 7/16, Flat Head Slot, Stainless Steel

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 adapter in the spectrometer and remove the adapter. If the spacer plate has been removed, reinstall it on the adapter.

3. Loosen the locking ring and remove the drum housing from the front of detector.

4. Attach the Acton adapter to the drum housing (dashed line in illustration) with the flathead screws provided.

5. Remount the drum housing to the front of the detector.

6. Gently insert the adapter into the spectrometer 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.
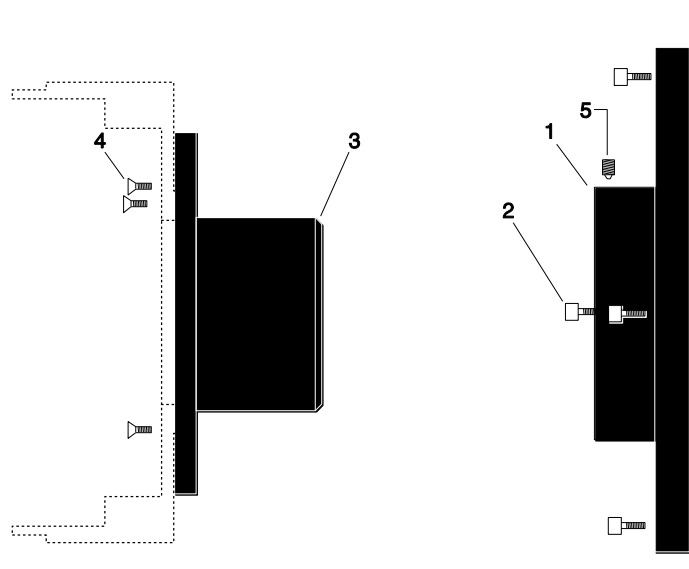
Acton (NTE/NTE 2/XP/XTE)

Adapter and Spacer Plate
(supplied with spectrometer)

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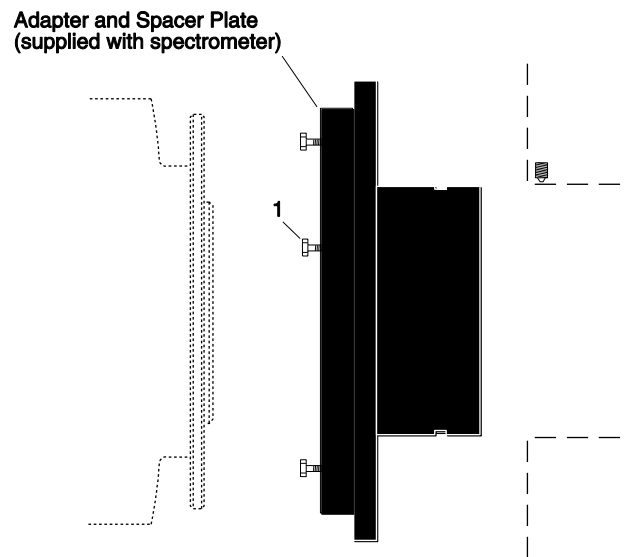
Qty	P/N	Description
1. 3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel

Assembly Instructions

1. Make sure that the shipping cover has been removed from the detector port on the spectrometer.

2. Loosen the setscrews holding the Acton adapter in the spectrometer and remove the adapter. If the spacer plate has been removed, reinstall it on the adapter.

3. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to the adapter.

4. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

5. Tighten the screws.

6. Gently insert the adapter into the spectrometer 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.

Chromex 250 IS (LN with shutter)
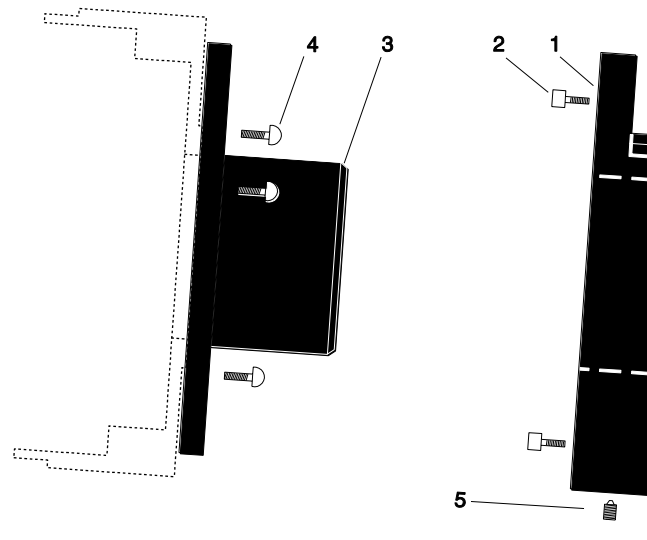
	Qty	P/N	Description
1.	1	2517-0901	Plate, Adapter-Female
2.	4	2826-0283	Screw, 10-32 × 3/4, Socket head, Stainless Steel, Hex, Black
3.	1	2518-0107	Adapter-Male, HR320
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head Allen Hex, Stainless Steel
5.	1	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen 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 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.
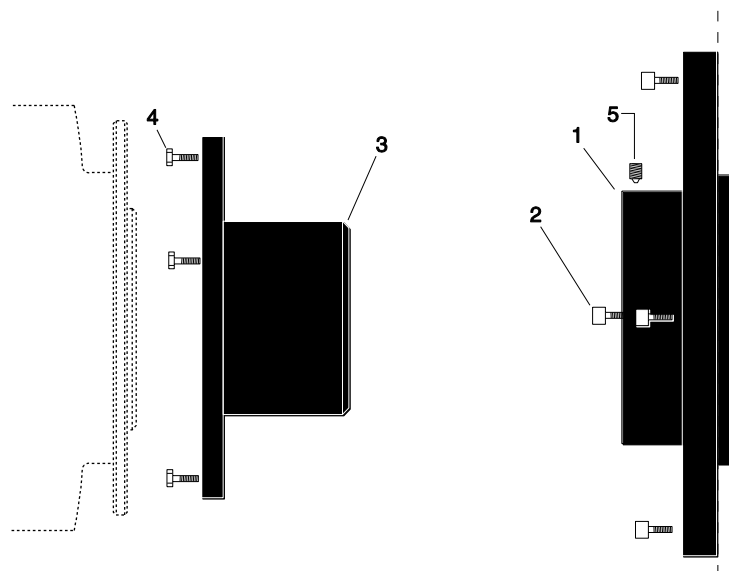
Chromex 250 IS (LN without shutter)

	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	2518-0227	Adapter-Male, ICCD Diode Array
4.	3	2826-0251	Screw, 10-32 × 7/16, Flat Head Slot, 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 wall (dashed line in illustration) with the socket head screws provided.

2. Loosen the locking ring and remove the drum housing from the front of detector.

3. Attach part 3 to the drum housing (dashed line in illustration) with the flathead screws provided.

4. Remount the drum housing to the front of the detector.

5. 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.

Chromex 250 IS (NTE/NTE 2/XP/XTE)

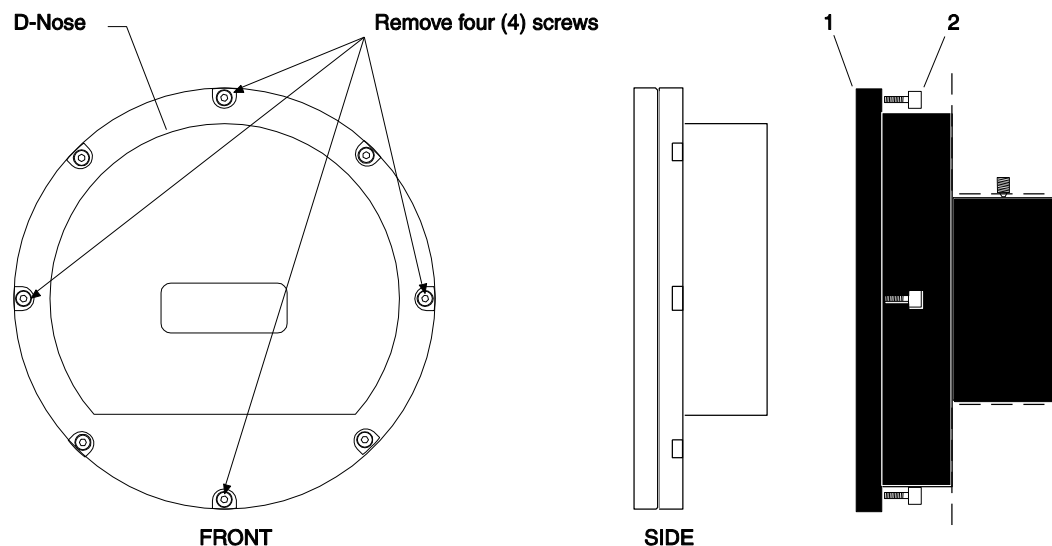|	Qty	P/N	Description
1.	1	2517-0901	Plate, Adapter-Female
2.	4	2826-0283	Screw, 10-32 × 3/4, Socket Head, Stainless Steel, Hex, Black
3.	1	2518-0227	Adapter-Male, ICCD Diode Array
4.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel
5.	1	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws provided.

2. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to part 3.

3. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

4. Tighten the screws.

5. 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)

	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 (Prontor)
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 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 320 (LN without shutter)
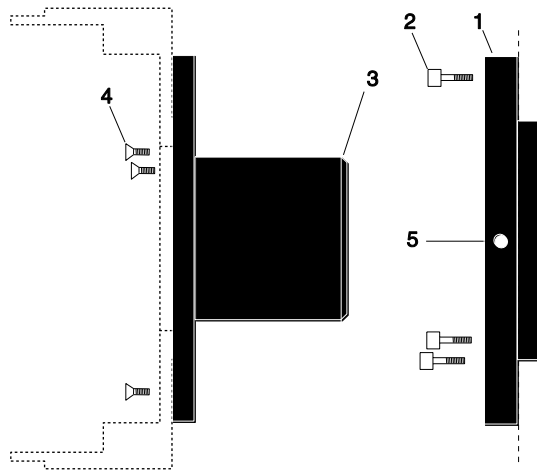
	Qty	P/N	Description
1.	1	2518-0044	Flange-Female, Mechanical, ISA, HR320
2.	3	2826-0053	Screw, 10-32 × 7/16, Socket Head Cap Hex, Stainless Steel
3.	1	2518-0045	Flange-Male, Detector Mate
4.	3	2826-0251	Screw, 10-32 × 7/16, Flat Head Slot, Stainless Steel
5.	1	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer with socket head screws provided.

2. Loosen the locking ring and remove the drum housing from the front of detector.

3. Attach part 3 to the drum housing (dashed line in illustration) with the flathead screws.

4. Remount the drum housing to the front of the detector.

5. 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 (NTE/NTE 2/XP/XTE)
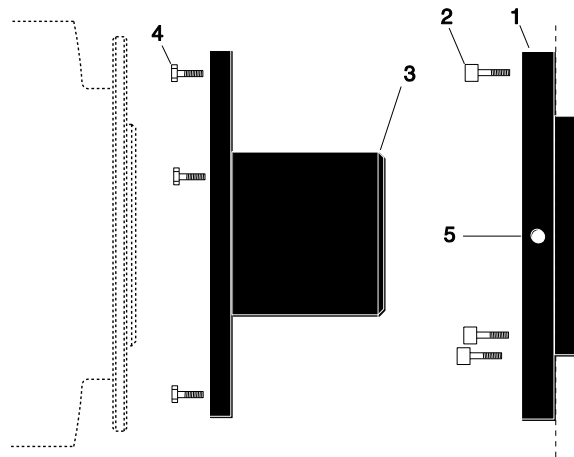
	Qty	P/N	Description
1.	1	2518-0044	Flange-Female, Mechanical, ISA, HR320
2.	3	2826-0053	Screw, 10-32 × 7/16, Socket Head Cap Hex, Stainless Steel
3.	1	2518-0045	Flange-Male, Detector Mate
4.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel
5.	1	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws provided.

2. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to part 3.

3. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

4. Tighten the screws.

5. 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 640 (LN without shutter)

	Qty	P/N	Description
1.	1	2518-0203	Adapter-F, HR-640
2.	4	2826-0144	Screw, M4x.7x14 mm, Socket Head, Hex, Stainless Steel
3.	1	2518-0227	Adapter-Male, ICCD Diode Array
4.	3	2826-0251	Screw, 10-32 × 7/16, Flat Head Slot, Stainless Steel
5.	2	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws.

2. Loosen the locking ring and remove the drum housing from the front of detector.

3. Attach part 3 to the drum housing (dashed line in illustration) with the flathead screws.

4. Remount the drum housing to the front of the detector.

5. 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.

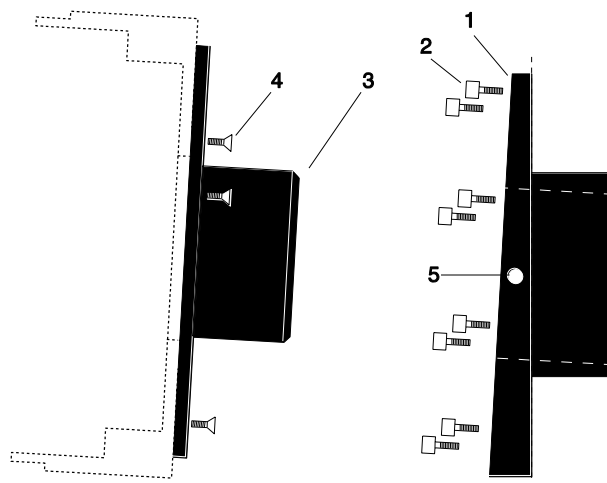# ISA HR 640 (NTE/NTE 2/XP/XTE)

	Qty	P/N	Description
1.	1	2518-0203	Adapter-F, HR-640
2.	4	2826-0144	Screw, M4x.7x14 mm, Socket Head, Hex, Stainless Steel
3.	1	2518-0227	Adapter-Male, ICCD Diode Array
4.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel
5.	2	2826-0082	Set Screw, 10-32 × 1/4, Stainless Steel, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws provided.

2. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to part 3.

3. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

4. Tighten the screws.

5. 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 (LN without shutter)

	Qty	P/N	Description
1.	1	2518-0838	TRIAX 320 TE/LN Male D Nose Adapter
2.	4	2826-0177	Screw 4-40 × 1/2, Socket Head, Hex, Stainless Steel

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 Spec-10 LN-cooled detector that you already own.

Assembly Instructions

1. Loosen the locking ring and remove the drum housing from the front of detector.

2. Remove four (4) of the socket head screws from the D-Nose (see illustration above) and store these screws.

3. Using the four (4) screws provided with the adapter kit, mount part 1 to the front of the detector.

4. Remove the spectrometer cover.

5. Insert part 1 into the spectrometer and fasten it in place with the spectrometer setscrews.

6. 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.

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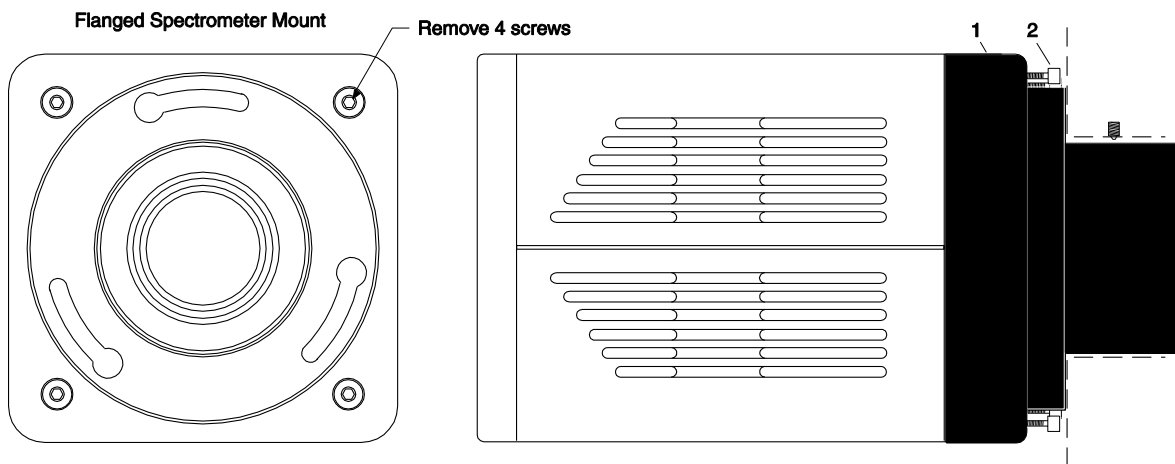
Qty	P/N	Description
1.	1	2518-1000	Adapter, TRIAX, NTE, 7377, 7376, 7413
2.	4	2826-0191	Screw, 10-32 × 5/8, Socket Head, Stainless Steel, Hex, Black

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 Spec-10 NTE or NTE 2 detector 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.

SPEX 270M (LN with shutter)
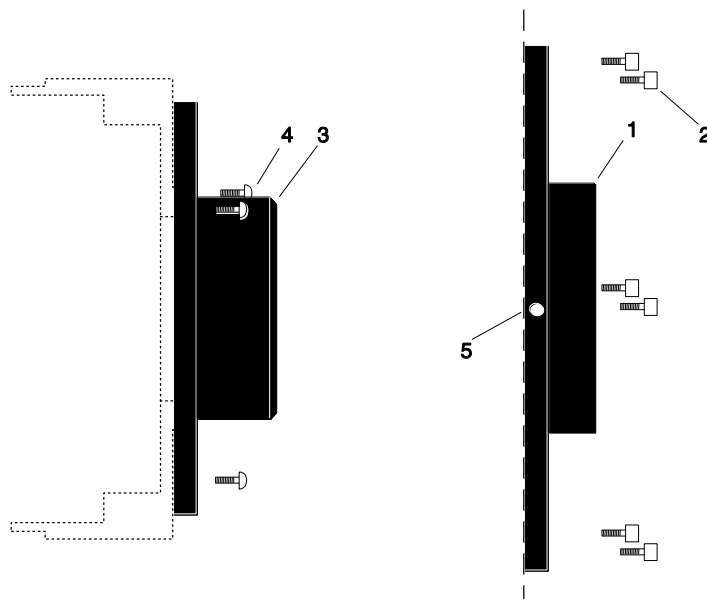
	Qty	P/N	Description
1.	1	2518-0691	Female Adapter Plate, 2.400 ID
2.	6	2826-0068	Screw, 6-32 × 3/8, Socket Head, Cap, Stainless Steel
3.	1	2518-0690	Adapter, Focusing, Male, Spec 270
4.	3	2826-0127	Screw, 10-32 × 1/4, Button Head, Hex, Stainless Steel
5.	2	2826-0073	Screw 6-32 × 1/8, Set, Allen Hex, 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 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.
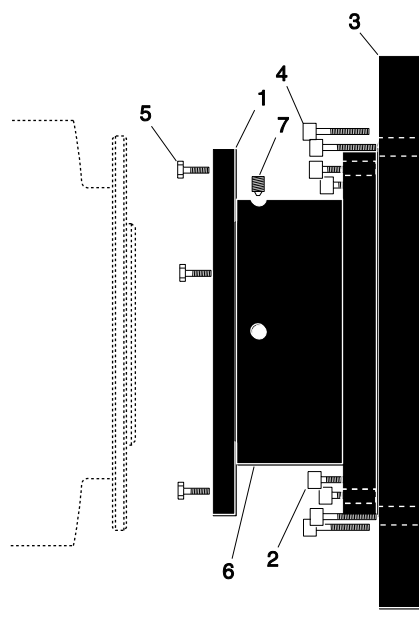
SPEX 270M (LN without shutter)
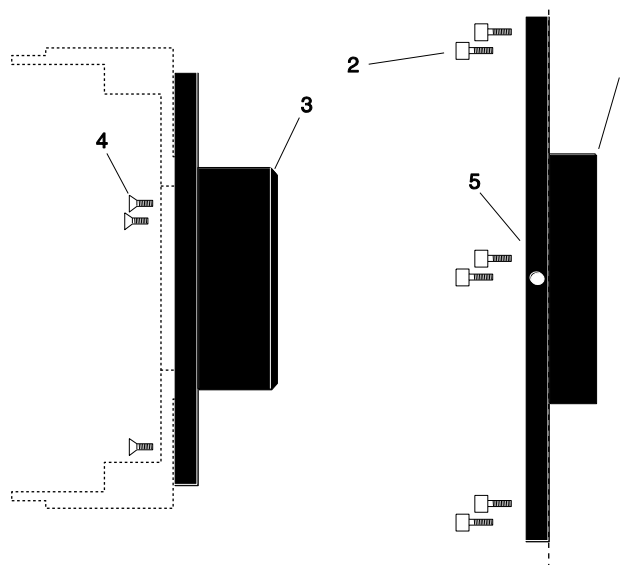
	Qty	P/N	Description
1.	1	2518-0691	Female Adapter Plate, 2.400 ID
2.	6	2826-0068	Screw, 6-32 × 3/8. Socket Head, Hex, Stainless Steel
3.	1	2518-0690	Adapter Male, Focusing, Male, Spec 270
4.	3	2826-0251	Screw, 10-32 × 7/16, Flat Head Slot, Stainless Steel
5.	2	2826-0019	Set Screw 8-32 × 3/16, Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws provided.

2. Loosen the locking ring and remove the drum housing from the front of detector.

3. Attach part 3 to the drum housing (dashed line in illustration) with the flathead screws provided.

4. Remount the drum housing to the front of the detector.

5. 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 270M (NTE/NTE 2/XP/XTE)
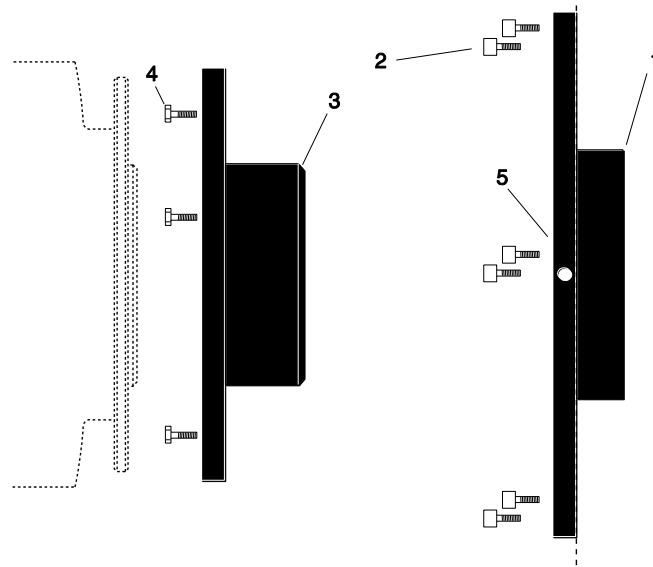
	Qty	P/N	Description
1.	1	2518-0691	Female Adapter Plate, 2.400 ID
2.	6	2826-0068	Screw, 6-32 × 3/8. Socket Head, Hex, Stainless Steel
3.	1	2518-0690	Adapter Male, Focusing, Male, Spec 270
4.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel
5.	2	2826-0019	Set Screw 8-32 × 3/16, Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws provided.

2. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to part 3.

3. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

4. Tighten the screws.

5. 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 500M (LN with 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 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 500M (LN without shutter)
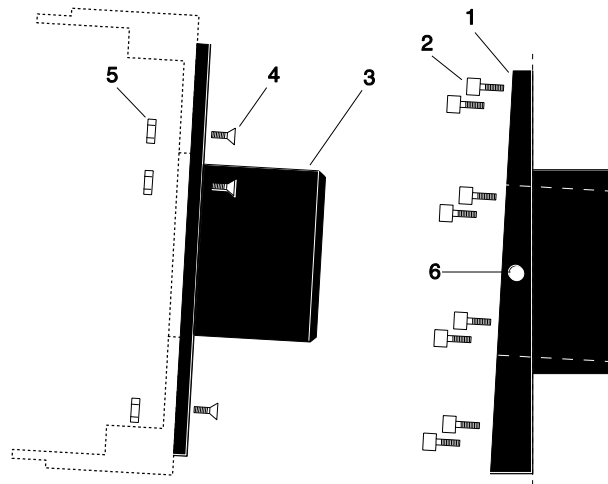
Qty	P/N	Description
1.	1	2517-0214	Adapter-Female, Spex 500M
2.	8	2826-0170	Screw, 1/4-20 × 0.5L, Low Socket Head Cap
3.	1	2518-0291	Adapter Male, Spex 500M
4.	3	2826-0088	Screw 10-32 × 1/2, Flat Head, Allen Hex Cap, Stainless Steel,
5.	3	2827-0010	10-32 Nut, Stainless Steel
6.	2	2826-0055	Set Screw 8-32 × 1/4, Allen Hex, Nylon Tip

Assembly Instructions

1. Insert part 1 into the spectrometer wall (dashed line in illustration) and fasten with the socket head screws provided.

2. Loosen the locking ring and remove the drum housing from the front of detector.

3. Attach part 3 to the drum housing (dashed line in illustration) with the flathead screws and nuts provided.

4. Remount the drum housing to the front of the detector.

5. 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 500M (NTE/NTE 2/XP/XTE)
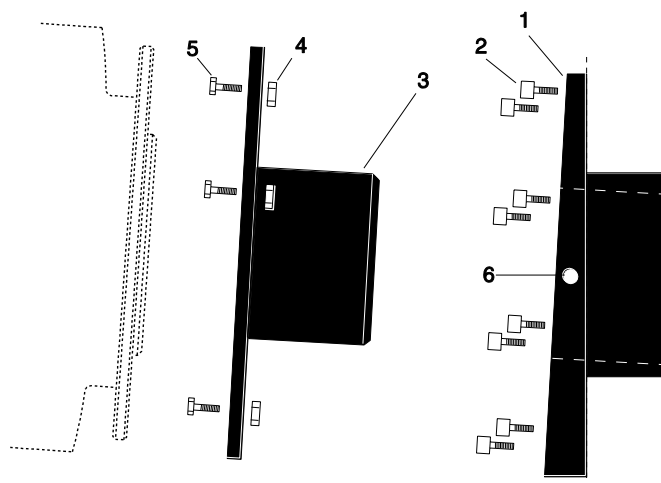
Qty	P/N	Description
1.	1	2517-0214	Adapter-Female, Spex 500M
2.	8	2826-0170	Screw, 1/4-20 × 0.5L, Low Socket Head Cap
3.	1	2518-0291	Adapter Male, Spex 500M
4.	3	2827-0010	10-32 Nut, Stainless Steel
5.	3	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel
6.	2	2826-0055	Set Screw 8-32 × 1/4, Allen Hex, Nylon Tip

Assembly Instructions

1. Attach part 1 to the spectrometer wall (dashed line in illustration) with the socket head screws provided.

2. Leaving 1/4" of thread exposed, mount the three (3) hex head screws and nuts to part 3.

3. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

4. Tighten the screws.

5. 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)
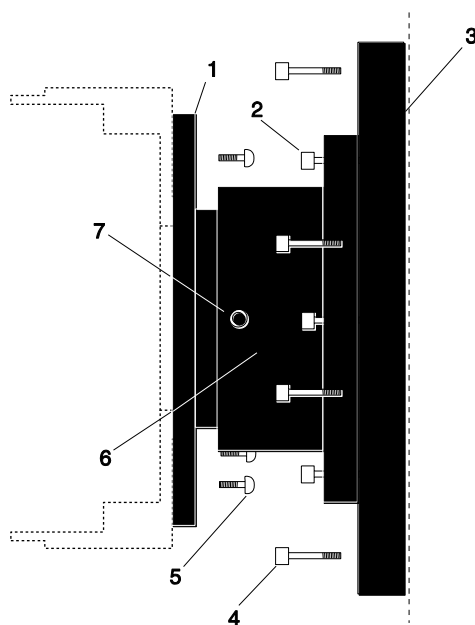
	Qty	P/N	Description
1.	1	2518-0184	Adapter-Male, LN/TE, CCD/For Spex TripleMate
2.	4	2826-0128	Screw, 10-32 × 5/8, Socket Head Cap, Stainless Steel,
3.	1	2517-0163	Slit Mount, Spex
4.	4	2826-0129	Screw, 1/4-20 × 3/4, Socket Head Cap, Stainless Steel
5.	3	2826-0127	Screw, 10-32 × 1/4, Button Head, Hex, 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 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.

SPEX TripleMate (LN without shutter)
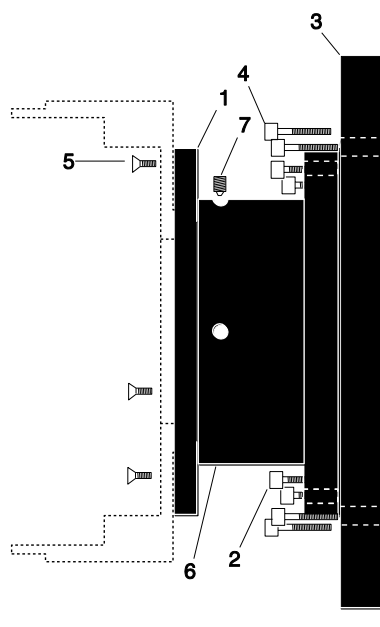
	Qty	P/N	Description
1.	1	2518-0183	Adapter-Male, ICCD/For Spex TripleMate
2.	4	2826-0128	Screw, 10-32 × 5/8, Socket Head Cap, Stainless Steel
3.	1	2517-0163	Slit Mount, Spex
4.	4	2826-0129	Screw, 1/4-20 × 3/4, Socket Head Cap, Stainless Steel
5.	3	2826-0251	Screw, 10-32 × 7/16, Flat Head Slot, Stainless Steel
6.	1	2518-0185	Adapter-Female, Flange Spex
7.	2	2826-0070	Set Screw, 6-32 × 3/16, Stainless Steel, Allen Hex
	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 (dashed line in illustration).

2. Loosen the locking ring and remove the drum housing from the front of detector.

3. Attach the drum housing (dashed line in illustration) to part 1 with the flathead screws.

4. Remount the drum housing to the front of the detector.

5. Tighten down the setscrews if they are loose.

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 (NTE/NTE 2/XP/XTE)

	Qty	P/N	Description
1.	1	2518-0183	Adapter-Male, ICCD/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	2826-0120	Screw, 10-32 × 1/2, Hex Head, Stainless Steel
6.	1	2518-0185	Adapter-Female, Flange Spex
7.	2	2826-0070	Set Screw, 6-32 × 3/16, Stainless Steel, Allen Hex
	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 (dashed line in illustration).

2. Leaving 1/4" of thread exposed, mount the three (3) hex head screws to part 1.

3. Mount the adapter to the detector flange and rotate the adapter so the screw heads are over the narrow end of the slots.

4. Tighten the setscrews.

5. Tighten the hex head screws.

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.

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Appendix D

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 (EZ-DLLS).

- Some 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	WinX2.5.18.1
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	WinX2.5.18.1
Custom Chip	YES	WinX2.5.18.1
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 11. 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 11. Features Supported under USB 2.0

Declarations of Conformity

This section of the SPEC-10 manual contains the declarations of conformity for Spec-10 systems. Spec-10 systems encompass LN-cooled, NTE-cooled, NTE 2-cooled, TEA-cooled, XTE-cooled, and lifetime vacuum XP 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 1 MHz 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 CONTROLLER w/NTE 2 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 1 MHz 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

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(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 HIGH POWER CONTROLLER
w/ XTE 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: April 1, 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-133A 2 MHz PCI CONTROLLER with SPEC-10 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: February 4, 2004
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 SPEC-10 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
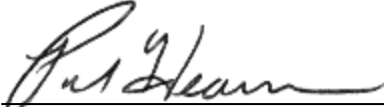
EMC DIRECTIVE 89/336/EEC with Amending Directive 93/68/EEC.

Date: February 4, 2004
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. Se*e 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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