

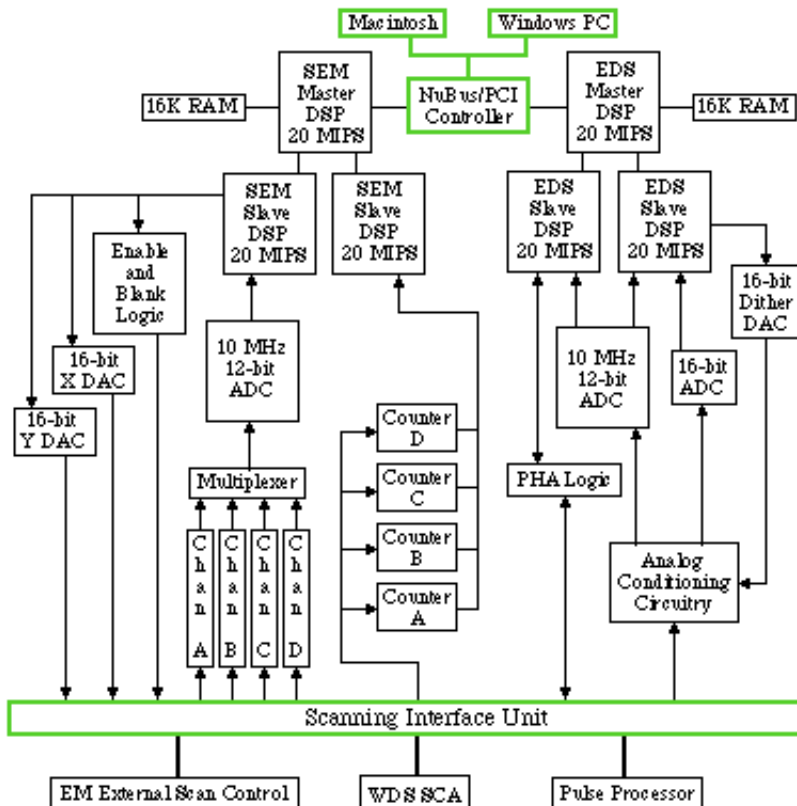
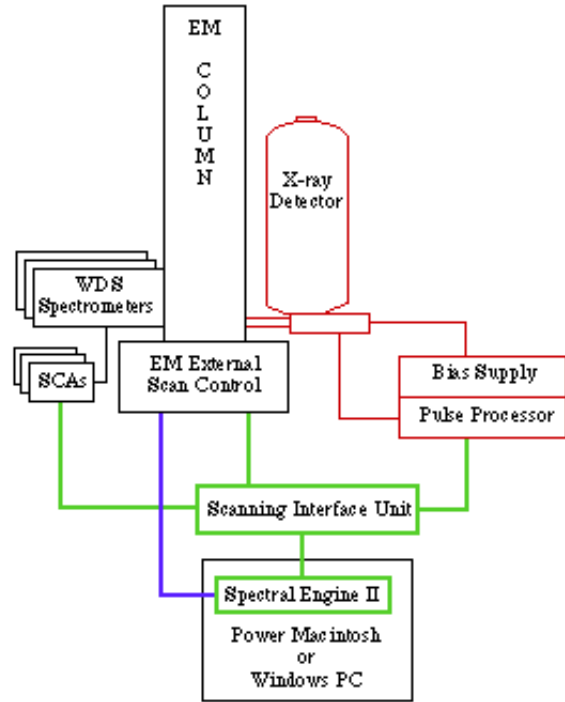
Hardware and Installation

Introduction

The 4pi system becomes part of a digital imaging, EDX, and/or WDS system as shown below:

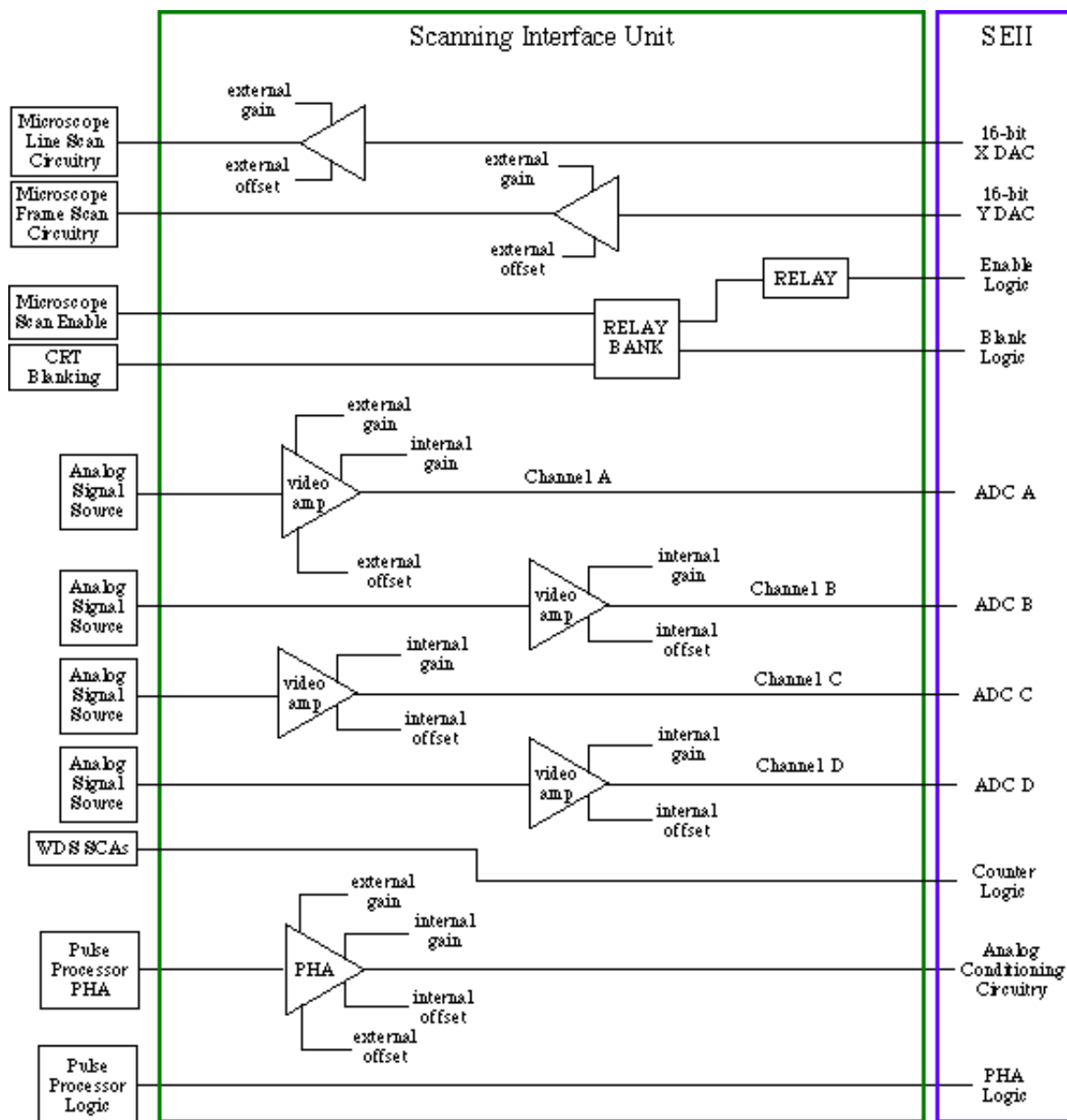
The 4pi hardware is marked in **green**. The **Spectral Engine II** (SEII) is a single card that plugs into a PCI slot on a Power Macintosh or Windows-based computer. The **Scanning Interface Unit** (SIU) is an external box that connects to the SEII via a shielded 37-pin cable. The SIU connects to the electron microscope's external scan control, the EDX pulse processor, and the WDS spectrometer counter outputs via cables that we supply. Optionally, the SEII (2.2rev2 and higher) can supply SCA outputs to the electron microscope for traditional x-ray dot mapping (**blue**).

For a complete EDX system, 4pi supplies a pulse processor and x-ray detector (**red**), or supplies custom cabling to your existing pulse processor and x-ray detector.



A block diagram of the **Spectral Engine II** card is shown to the left. It connects to the Scanning Interface Unit via a 37-pin cable.

A block diagram of the **Scanning Interface Unit** is shown below. On one end, it connects to the Spectral Engine II card, on the other end it connects to the electron microscope scan control, the pulse processor, and WDS counters:



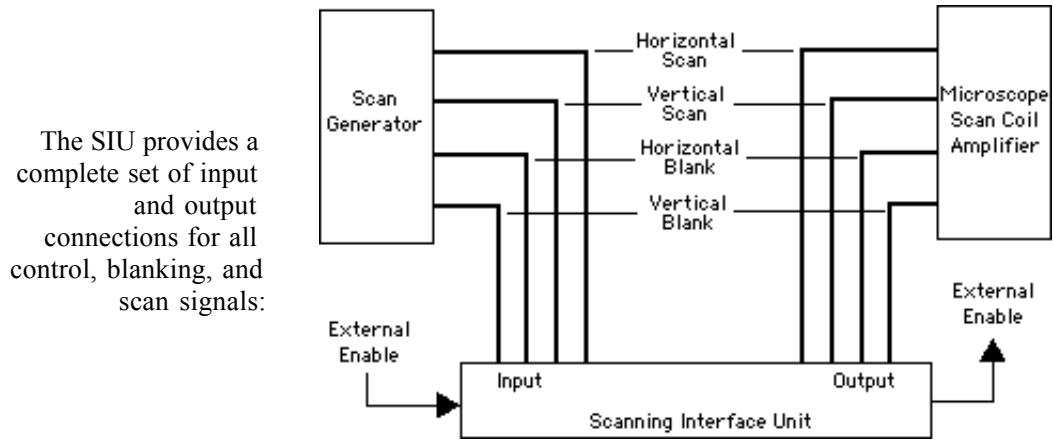
Theory of Operation

Microscope Scanning and Control Theory of Operation:

The Spectral Engine (SEII) creates line (X) and frame (Y) scan signals using 16-bit DACs. These signals are routed through SIU buffer amplifiers, each with independent front-panel gain and offset controls to match the scan amplitude to that required by the microscope scan circuitry. Using the Revolution software, the X-Y assignments can be reversed. The direction of each scan

can be independently reversed as well. Revolution's [Hardware Setup Preferences](#) control this aspect of operation.

The SEII uses a single enable signal to control a relay bank in the SIU. The relay bank connects to the microscope scan-control circuitry to provide external scan control activation and/or switching, and video-feedback signals. When the external scan is enabled, the microscope CRT/photo-CRT displays are blanked to prevent any possibility of damage to them (i.e., burning a spot in the CRT phosphor) should the external scan prematurely stop. In the case of a digital microscope with internal frame buffer, the video signal is set to blank to avoid a distorted image on the microscope's video screen. Connections usually consist of a combination of BNC and other connectors, but may be more complicated. 4pi provides a custom cable to connect the SIU to the microscope.



The "Scan Generator" can be one of three sources: 1) the microscope itself; 2) the 4pi Spectral Engine II card; or 3) a third-party scan control system. The SIU provides maximum configuration capability, and via relay control can switch the complete set of signals, allowing either the alternate scan control system or the 4pi system to control the microscope, all without removing any physical cables or connections.

The configuration of the SIU is determined before installation and is set at the factory. Typically, final adjustments to the scan video amplitudes must be made by the installer or customer. Both the final adjustments and virtually any configuration changes can be made easily by the end-user.

The following table is a listing of the possible external connections to a microscope from the SIU; pin numbers for any connector represent "signal/ground." Signal directions are shown with an arrow. Depending on the microscope, not all connections may be required:

S(T)EM Function	direction	SIU Function	SIU Connection
Internal/External Control	→	External Enable IN	Scanning I/O B, pin 1/14
Internal/External Control	←	External Enable OUT	Scanning I/O B, pin 2/15
Scan Gen Horz Blank	→	Horz Blank IN	Scanning I/O B, pin 9/22
Scan Gen Vert Blank	→	Vert Blank IN	Scanning I/O B, pin 10/23
Scan Gen Horz Scan	→	Horz Scan IN	Scanning I/O B, pin 11/24
Scan Gen Vert Scan	→	Vert Scan IN	Scanning I/O B, pin 12/25
Scan Coil Horz Blank	←	Horz Blank OUT	Scanning I/O B, pin 7/20
Scan Coil Vert Blank	←	Vert Blank OUT	Scanning I/O B, pin 8/21
Scan Coil Horz Scan	←	Horz Scan OUT	Scanning I/O B, pin 3/16
Scan Coil Vert Scan	←	Vert Scan OUT	Scanning I/O B, pin 4/17
BE/SE Video Amp OUT	→	SEM Video A IN	Scanning I/O B, pin 5/18
CRTs etc	←	SEM Video A OUT	Scanning I/O B, pin 6/19
user-specified video	→	SEM Video B IN	Scanning I/O A, pin 4/17
user-specified video	→	SEM Video B IN	Scanning I/O A, pin 5/18
user-specified video	→	SEM Video D IN	Scanning I/O A, pin 6/19

Imaging Theory of Operation:

The SEII creates an image of any analog signal by digitizing that signal. The maximum allowed signal is ± 15 volts. Typically the analog signal source is video from either a backscattered or secondary electron detector, but it can be an analog signal from any detector connected to the microscope (e.g., absorbed current, EBIC, or cathodoluminescence detectors).

4pi's digital imaging hardware must be able to access to the analog signal sources. Often these connections are available via panels supplied by the microscope manufacturer and are terminated with BNC or other standard connectors; however, this may not be the case if the microscope is not configured for external scan control. 4pi works with the customer and, if necessary, the electron microscope manufacturer to verify a microscope's external scan configuration. These details are resolved during the ordering process.

The SIU independently buffers up to 4 analog channels (Channels A, B, C, and D). **Channel A** has front-panel (external) fine-gain and offset controls and one internal coarse-gain control, while **Channels B, C, and D** each have internal gain and offset controls. These controls are typically used to set brightness and contrast independently of their instrument sources.

These 4 analog inputs are switched on the SEII card into a single ADC. The Revolution software controls the selection of the signals and the order in which they are read. The order of signal acquisition is determined by software settings. Refer to the [SEM Image Preferences](#) and [SEM Linescan Preferences](#).

EDX Theory of Operation:

Energy Dispersive X-ray Spectroscopy (EDX) is the technique of measuring the energies of x-rays emitted as the result of electron bombardment of a sample. A **pulse processor** handles the conversion of the raw detector signal so that it can be digitized for display as a spectrum. [PHA](#) pulses from the pulse processor are buffered to the SIU's gain and offset circuitry and forwarded to the SEII, which measures the amplitude of each pulse using precision ADC and signal conditioning circuitry. In essence, the existing ADC in the pulse processor is replaced by the MCA in the SEII. The pulses are binned in 4096 channels, each channel corresponding to a range of x-ray energies. This information is then passed via the driver to Revolution for display and analysis.

Via the SIU, the SEII can be interfaced to a number of existing pulse processors, whose operation is known by Revolution's [Hardware Setup Preferences](#). Further software configuration of EDX operation is accessible from Revolution's [X-ray Probe Preferences](#). The EDX and scanning/imaging capabilities of the SEII are independent; however, the two can be combined for x-ray mapping capability (see below) or collecting spectrum-per-pixel data sets for spectrum analysis.

4pi provides a custom cable to connect the SIU PHA Logic I/O to the pulse processor's front and/or rear panel. Connections usually consist of BNC connectors, but may be more complicated. Some pulse processors allow for direct connection without an SIU, if the system is EDX-only. The following table is a listing of the possible external connections to a pulse processor from the SIU; pin numbers for the PHA Logic I/O connector represent "signal/ground." Signal directions are shown with an arrow. Depending on the pulse processor, not all of the connections may be required:

Pulse Processor Function	direction	SIU Function	SIU Connection
ADC Busy/Inhibit	←	vADC_DT	PHA Logic I/O, pin 2/15
Pulse Reject	→	vPUR	PHA Logic I/O, pin 3/16
Livetime/Deadtime	→	vDT	PHA Logic I/O, pin 4/17
Fast Channel	→	FCHAN	PHA Logic I/O, pin 6/19
Analog Pulse Output	→	PHA Pulse	PHA Input, BNC

X-ray Mapping Theory of Operation:

X-ray mapping combines microscope scanning control and EDX spectrum acquisition to build an image of x-ray count intensity at each pixel for a particular [ROI](#) or set of ROIs. Software configuration changes specific to mapping are made in Revolution's [X-ray Imaging Preferences](#).

WDS Theory of Operation:

Wavelength Dispersive Spectroscopy (WDS) refines the EDX technique by using a crystal spectrometer to significantly narrow the detected X-ray energy linewidth. Typically, a single channel analyzer (SCA) generates [TTL](#) pulses, one for each x-ray detected by the crystal spectrometer. The source of the pulses will depend on the design of your WDS system. Some manufacturers provide convenient BNC external outputs for tapping the spectrometer's detected x-ray counts. The pulses should be TTL-level (0 or +5 VDC) and may be TTL-positive or TTL-negative. 4pi Analysis does not supply any hardware or software to control the operation of wavelength spectrometers. You must use other software/hardware to position the spectrometer on the x-ray peak and to set the spectrometer electronics.

The SEII counts the pulses on any of four independent counter inputs. Revolution creates a map based on the counts. Individual WDS counters are selected in Revolution [just as for analog channel selection](#).

The following table is a listing of the external connections to the crystal spectrometers from the SIU; pin numbers for the PHA Logic I/O connector represent "signal/ground." Signal directions are shown with an arrow.

Crystal Spectrometer Function	direction	SIU Function	SIU Connection
SCA Output 1	→	WDS Counter 1	PHA Logic I/O, pin 8/21
SCA Output 2	→	WDS Counter 2	PHA Logic I/O, pin 9/22
SCA Output 3	→	WDS Counter 3	PHA Logic I/O, pin 10/23
SCA Output 4	→	WDS Counter 4	PHA Logic I/O, pin 11/24

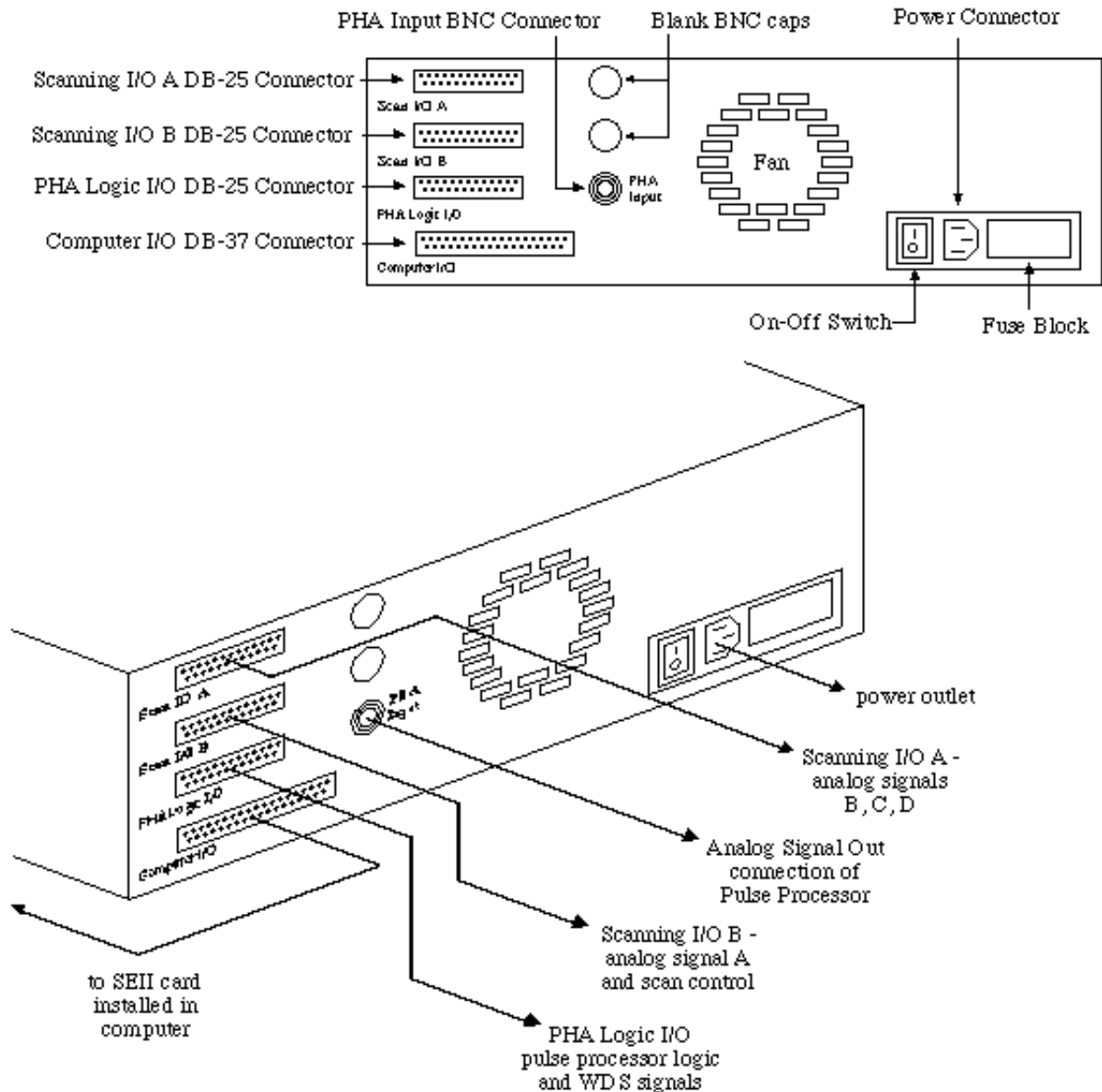
Unpacking

All items shipped FOB Durham NC are packed in standard cardboard containers. Open the containers and inspect for visual damage. Unpack the computer, SIU, and cabling only. **Unless otherwise instructed to by 4pi, do not open the Detector or CCD container(s) unless there is a need to inspect for apparent damage.** Handle all contents with the level of care typically expected for sensitive electronic equipment. Take special care to avoid damaging connectors while removing packing material. Avoid mishandling the circuit card to prevent damage to components or connections (for systems ordered with a computer, the 12-inch PCI card may already be installed by 4pi at the factory). Obey normal static electricity handling procedures. Do not stress cables by inadvertently straining connectors or bending the cables.

Immediately report any shipping damage to 4pi Analysis and to the shipping company. All items, packed and unpacked, should be set aside until the installer arrives on site, or other instructions are received from 4pi technical support.

Step-by-Step Installation Instructions

1. If your system includes a computer supplied by 4pi, the SEII card is likely already installed. Skip to step 5.
2. Open the computer following the procedure in the user's manual that was included with your computer. Remember to first turn off the power and completely remove any floppies from the floppy disk drives; on some computers, screws must be removed or the cover will not release.
3. On some computers, you must remove the metal slot cover on the inside rear of the computer corresponding to the chosen slot.
4. Insert the SEII card into the chosen slot. Since the card has on-board LED(s) that continuously blink to indicate successful loading of the driver, **we suggest that you wait to close/reassemble the computer so that you can verify blinking during the first time the card is powered up.** Although the remaining software can now be installed before the hardware installation is finished, no data can be acquired until the complete connection to the microscope and/or pulse processor (steps 5-10) are completed.
5. Familiarize yourself with the rear-panel layout of the 4pi Scanning Interface Unit (SIU), shown below.



6. Following the rear-panel diagram, connect the 37-pin cable between the SEII (DB-37 connector on rear of computer card) and the SIU's DB-37 **Computer I/O** connector. On older 4pi systems, this cable is a **single** flat ground-plane ribbon (on really old 4pi systems, 2 ribbon cables may be encountered; such an installation falls outside the scope of this document and 4pi support should be contacted). On newer systems, this cable is a bundled set of twisted shielded pairs. **If the cable is a ribbon type, take care to not bend it excessively.** Note that the DB-37 connectors on either end of this cable are male; they are interchangeable. Also, make sure each DB-37 connector is fully seated in its receptacle (this is especially important for the SIU — even though the jack screws may be tightened fully, it may still be possible to seat the connector further into the receptacle). DB-37 connector pin definitions are provided further down in this document.
7. If the system is to acquire digital images, connect the SEM cable(s) to the **Scanning I/O B** and, if necessary, the **Scanning I/O A** DB-25 connectors on the rear of the SIU. Unless custom video capabilities have been specified, only the Scanning I/O B cable will be present. Connect the other end of the SEM cable(s) to the appropriate external scan control and/or image connectors on the SEM. Cable labeling has been provided at both ends to make this as straightforward as possible; however, there are often questions involving the precise connections. Contact 4pi technical support for assistance. Scanning I/O A and B pin definitions are provided further down in this document.

8. If the system is to acquire EDX x-ray spectra and/or x-ray maps, connect the EDX cable to the **PHA Logic I/O** (DB-25) and **PHA Input** (BNC) connectors on the rear of the SIU. Connect the other end of the EDX cable to the appropriate connectors on the pulse processor. Cable labeling has been provided at both ends to make this as straightforward as possible; however, there are often questions involving the precise connections. Contact 4pi technical support for assistance. PHA Logic I/O pin definitions are provided further down in this document.
9. If the system is to acquire WDS maps, the PHA Logic I/O connector will also have cables to connect to the crystal spectrometer(s). Labeling has been provided to make this as straightforward as possible. The WDS pin definitions are provided further down in this document as part of the PHA Logic I/O pin definitions.

Certain pulse processor connections are more complex than others and are not detailed here. In addition, some microscopes may not be configured to factory specs and will require special instructions. Contact 4pi directly for assistance in making any SEM or pulse processor connections.

10. **Hasp Installation.** Revolution software requires the use of a hasp (also known as a dongle). If Revolution does not detect the presence of a hasp, it will revert to demo mode. On Macintosh, the hasp can be either an ADB or USB type. On Windows, the hasp can be either a USB or parallel port type. For ADB (Mac) or parallel port (Win) hasps, the computer should be turned off. The parallel port hasp should be connected to the parallel port just as a printer is typically connected. The actual printer connector is then reconnected to the outside of the hasp. An ADB hasp can be connected serially as part of any ADB cable chain of the Macintosh, including either endpoint. A typical connection is directly to the keyboard. As with the parallel port hasp, the original ADB cable is reconnected in series with the hasp. The USB hasp, on the other hand, can be hot-plugged at any time (no need to turn computer off). There is no recommendation as to which USB port to plug the USB hasp into; however, if there are any problems, we recommend trying to plug the hasp directly into a rear panel USB port.
11. Properly connect the SIU power cord to a power outlet. Be sure all connectors are securely fastened. The hardware installation (other than reassembling the computer) is complete.