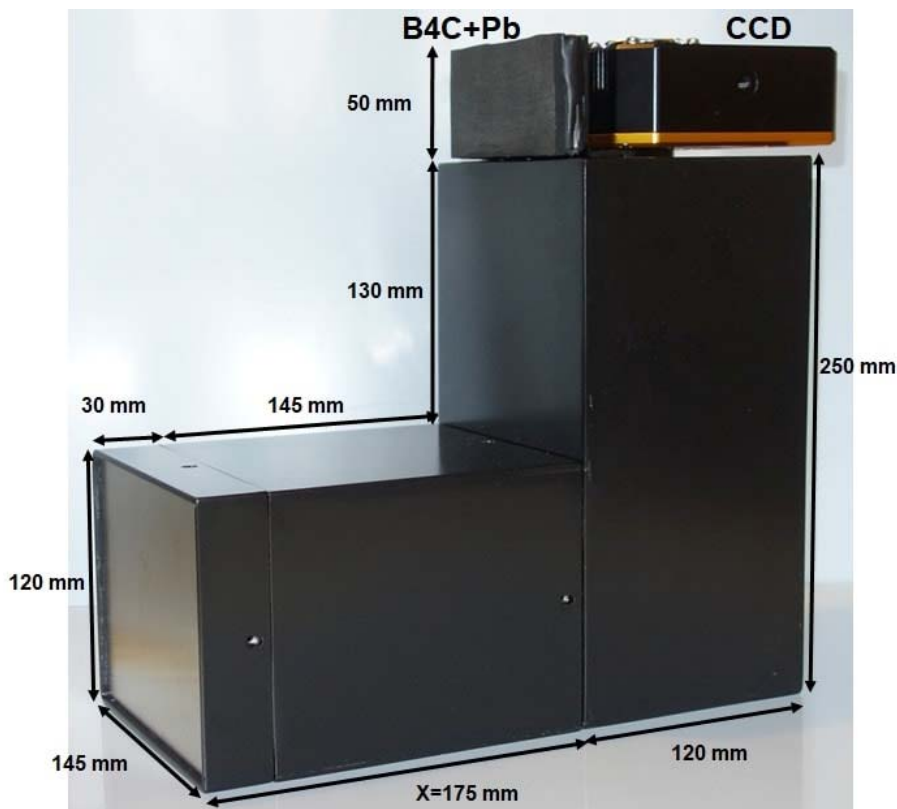


## NeutronOptics Hot Neutron Camera Assembly

Hot neutrons (2.45MeV or 14MeV) are very much harder to detect than thermal neutrons because they are not captured by nuclei to provide ionising fission fragments. However, scintillation in ZnS can be achieved with knock-on protons rather than  ${}^6\text{Li}$  fission, though long exposures are needed. RC-TriTec hot neutron scintillators use high density polypropylene PP as a source of knock-on protons.

### The NeutronOptics 125x100mm hot neutron tomography camera



Small D-D and D-T neutron generators are a promising development for low-cost neutron radiography, though the hot neutron flux is low. Even so, one of our 250x200mm cameras has already been used with an AdelphiTech 2.45 MeV D-D neutron generator to obtain radiographs with long exposures (~10 min).

The efficiency of the camera was increased by a factor of x4 by reducing the FOV to 125x100mm, and it can be further increased by a factor of x64 by binning pixels 8x8. Even after binning, the resolution with the smaller FOV will still be  $360\mu\text{m}$ , which is still amply sufficient with the 2.5mm PP/ZnS scintillators used for hot neutrons.

### The advantages of the NeutronOptics hot neutron tomography camera

- Very low noise with a Sony 1 inch [ICX694ALG](#) EXview HAD CCD II cooled by  $\Delta T = -35^\circ\text{C}$
- Very high sensitivity with a reduced Field-Of-View with on-chip binning to increase signal/noise
- Externally mounted CCD unit, making it easier to cool with dual fans (no need for water cooling)
- L-shaped (periscope) enclosure making it easier to protect the CCD from very penetrating radiation
- Absolute light-tight enclosure, allowing exposure times of 1+ hours with very low background
- Easy control of Newport-MicroControle sample turntables using simple Windows scripts
- **IMPORTANT. If the camera is being cooled, set "warm up" before shutting down**
- **IMPORTANT. Hot neutron generators emit gamma radiation which can damage the CCD**

## Installing the front-surfaced mirror

The camera may be delivered with the mirror (and a spare) packed separately for safety. To install it:

- Place the foot of the mirror below the labelled B<sub>4</sub>C ledge below the lens trap
- The plastic protected face with its instruction label must be on top
- Push the top of the mirror into the top labelled B<sub>4</sub>C holder
- When the camera assembly is complete, peel off the protective film
- The front aluminised face is protected by a transparent SiO layer for 95% reflectivity
- Do not touch or dirty the surface. If necessary, clean gently with window cleaner
- If necessary, use cyanolite glue spots for security, or glue a B<sub>4</sub>C strip to hold the mirror
- A spare mirror is provided



## Adjusting the lens focus

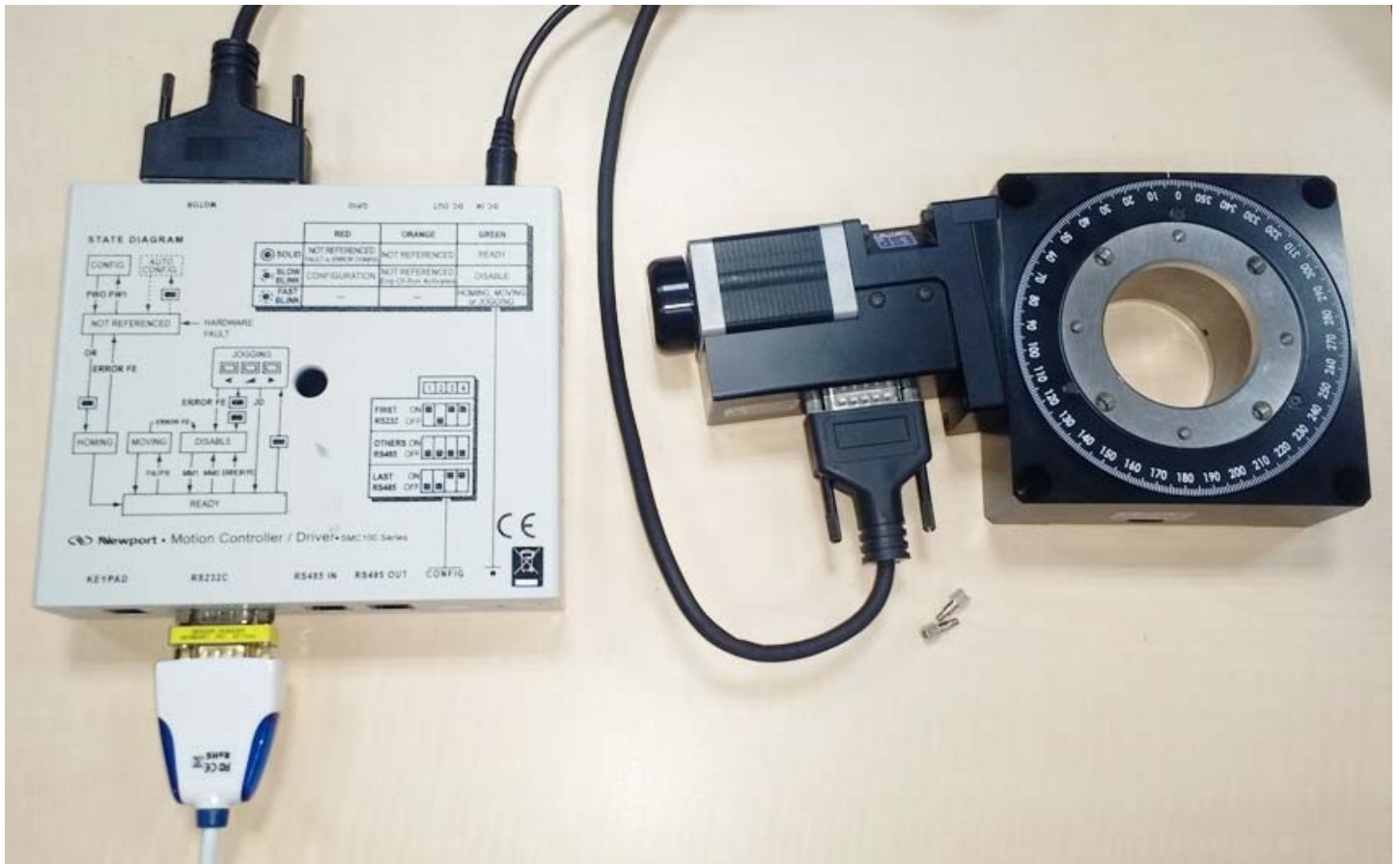
- Manual focussing must be done with light, not in the neutron beam
- Place a paper grid over the scintillator plate being careful not to touch it
- Slide the scintillator front-end box onto the main camera box
- Open the lens trap at the back of the camera to allow light to enter
- Connect the CCD cables and loop expose ~0.1s
- Adjust focus to obtain the sharpest image with light (bottom lock screw)
- When finished, fully open the lens aperture, remove the focusing grid & close the box
- Check that it is light-tight for a long exposure. Note that the camera is very sensitive and **scintillator afterglow can be seen for some minutes after exposure to light**
- **For very long exposures, wait several hours for the afterglow to completely disappear**



The CCD unit can be removed after first unscrewing the lens (left) to reveal three M3 bolts (right), which can then be unscrewed. There is no seal between the CCD unit and the box, and no adjustments, so the CCD unit can be easily replaced. **Do not touch the exposed surfaces of the CCD cover glass or lens**, the front of which is protected by a UV filter.



## Installing a Newport Micro-Controle Turntable for Tomography



We recommend the [Newport Micro-Controle URS turntables](#) which start at ~€2500, together with the [SMC100PP](#) motor controller (~€650) with the [SMC-PS80](#) power supply (~€93) and [SMC-USB](#) interface (~€63). The [URS150BPP](#) is usually sufficient, but for high loads, the [RV120BPP](#) can be used. These turntables use stepper motors for precise relative positioning without encoders.

You can use an [SMC-RC manual remote control](#) and display to rotate the turntable for alignment, and you may need an [M-SK-4MA M4](#) screw kit to assemble the optional mechanical components such as a manual [9204-M](#) Z-elevator, and X-Y translations [M-423](#) with [SM-25](#) Vernier Micrometers.

- Download [SMC100-V2.0.0.3.zip](#) right-click & "extract all", then launch **Drivers/ EasySync.exe**
- Run the **SMC100 Utility Installer** from the V2.0.0.3 folder. Use it to manually monitor the turntable
- Download and install [PuTTY](#) This will also install the command-line version called **Plink**
- Open a **Windows Command Prompt (cmd)** as Administrator and check that Plink runs
- Connect the **RS232C socket** on the controller to a USB socket on the computer using [SMC-USB](#)
- Connect the 25 pin **Motor socket** on the controller to the 15 pin turntable socket
- Connect the **DC-In socket** on the controller to the 48V power supply and plug it in
- In the **Windows Device Manager** check under Ports (COM) for a USB serial port
- Note the number of the of this USB serial port eg COM4: this is used in the **Orient.bat** script  
`C:\commands.bat | Plink -v -serial COM4 -sercfg 57600,8,n,1,N`  
 Plink opens COM4 and configures it as required for the controller
- The **Command.bat** script is then piped to the port to execute the following commands:  
`echo 1PR0.5`  
`timeout /t 1 /nobreak >nul 2>&1`  
`taskkill /f /IM Plink.exe`  
`exit`

Command **1PR0.5 steps motor 1 to Position Relative 0.5°**, we wait 1s, then kill Plink and exit

- These **\*.bat scripts** can be kept on disk **C:\** or anywhere else. Double click **Orient.bat** to test it
- The camera control software **ArtemisCapture** will execute Orient.bat after each image acquisition



## NeutronOptics Hot Neutron Camera Operation

Fast high resolution thermo-electrically cooled Sony 2750x2200 pixel CCD unit

- **X-ray Scintillator:** Interchangeable fast, fine x-ray scintillator
- **Neutron Scintillator:** Interchangeable high resolution neutron scintillator
- **Optics:** Interchangeable high resolution 25mm f/1.4 low-light lens
- **CCD Sensor:** 1 inch [Sony ICX694ALG EXview HAD CCD II](#)
- **Chip size:** 12.40x9.99 mm, diagonal 16 mm (Type 1")
- **Resolution:** 2750x2200 pixels (**90 µm resolution over 250x200mm**)
- **Pixel Size:** 4.54x4.54 µm (larger pixels & micro-lenses collect more light)
- **Binning:** from 2x2 to 8x8 (for boosted frame-rate and efficiency)
- **Region-of-Interest:** fully variable (for full resolution at higher frame-rate)
- **High sensitivity** (QE~75% at 500-600nm), low smear
- **Low dark current:** 0.002 electron/pixel/sec @ -10 °C
- **Full well capacity:** 20,000 electrons (large dynamic range)
- **A/D Conversion:** **16-bit 65536 levels** in [Flexible Image Transport System](#)
- **LiveView Mode:** 8 bit readout mode for faster readout
- **Digitisation Speed:** 6-12 MPixels/s
- **Readout Noise:** 6 e- at -10°C
- **Interface:** USB 2.0 High Speed with 10-20m amplified USB cables
- **Power:** Regulated 12v DC 2.5A, to EU, UK, US/Japan, AU/CN standards
- **Minimum Exposure Length:** 0.001 seconds
- **Maximum Exposure Length:** Unlimited
- **Cooling:** Regulated dual fan thermo-electric Peltier with max  $\Delta T = -35^{\circ}\text{C}$
- **External Trigger:** For synchronisation with sample environment
- **CCD Unit:** 120x120mm dimensions, 50mm height, 800g weight
- **SDK:** C++, VB Wrapper, .net Wrapper, [ImageJ](#), [LabView](#) drivers



- 1 - Vcc 3.3V
- 2 - GND
- 3 - GPIO Line 0
- 4 - GPIO Line 1
- 5 - Trigger Input
- 6 - Exposure Output



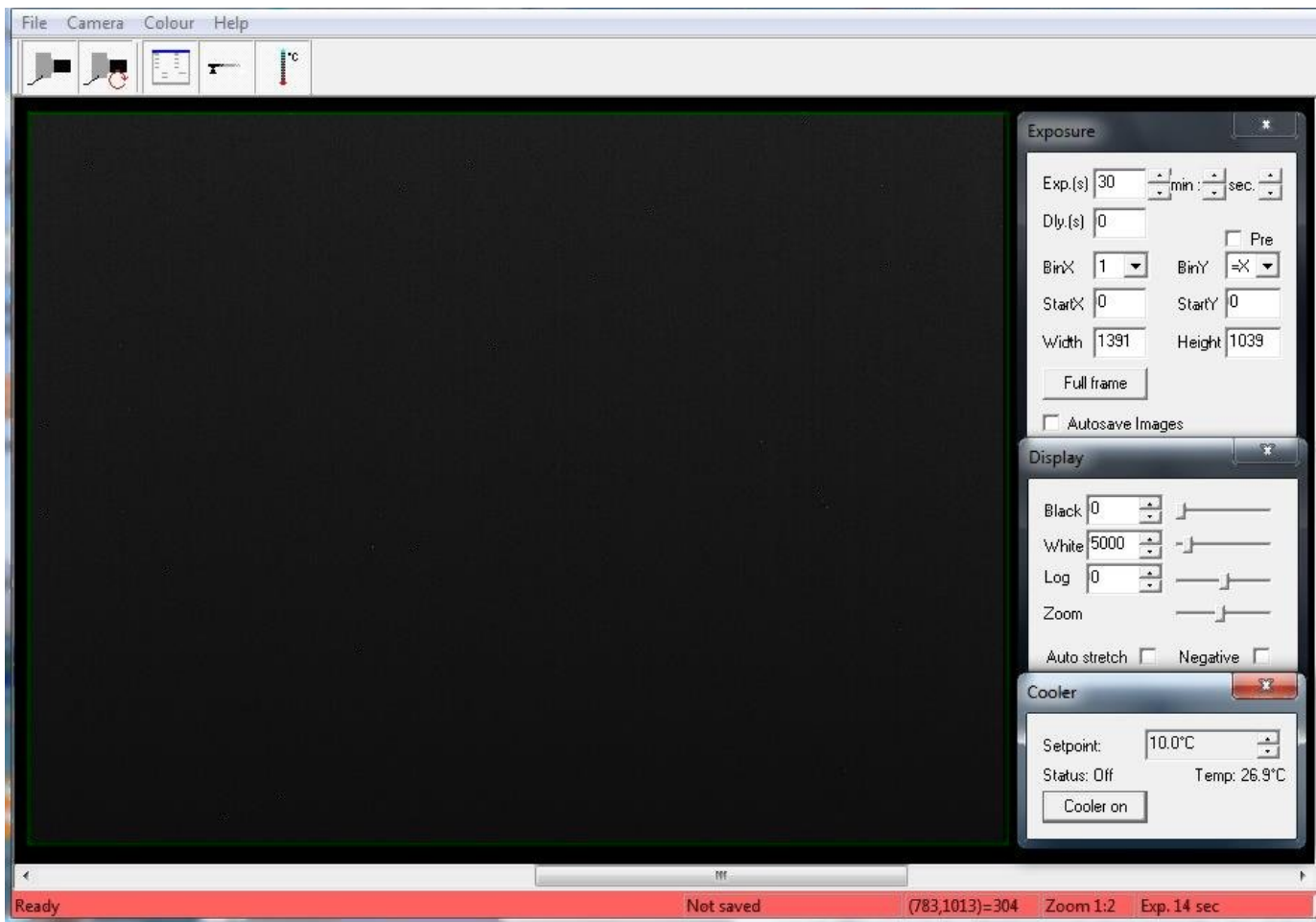
### Installing the Driver and Artemis Capture software

- Browse the CD & launch "SetupArtemisUniversal.exe" or "artemisinstaller.exe"
- This installs the driver & "ArtemisCapture" to control the camera
- You can also download and pre-install the [Artemis core software & drivers](#)
- Plug the 12V supply into the camera; the fan should start up
- Connect the 10m USB extension to the computer, and wait for its driver to be installed
- Then connect the camera to this cable, or directly to a USB port on your computer
- The computer should automatically search for and install the driver. Be patient !
- The Windows Device Manager should now show an ArtemisCCD USB controller
- Launch ArtemisCapture to control the camera (see next section)

- If the driver is not found automatically, try manual installation:
  - Click the Windows "Start" button and open "Devices and Printers"
  - Double-click the "Unknown Device", select "Hardware" then "Properties"
  - Click "Change Settings" under the "General" tab
  - Click "Update Driver" under the new "General" tab
  - Choose "Browse for Drivers" on the Product Software CD
  - Select the 32-bit or 64-bit driver from the drivers folder
  - Click "OK" then "Next" then accept and install the camera driver

## Using ArtemisCapture with the High Resolution Camera

Launch ArtemisCapture to display the image and controls. The "File" menu is used to save the last image, the "Camera" menu connects the camera if it is not done automatically, and the "Colour" menu should be set to "Raw". The icons under the menus launch a single exposure or continuous loop exposures. The three remaining icons open the Exposure, Display and Cooler tabs.



**On the "Exposure" tab:** (to speed up downloads e.g. when focussing with light)

- Set the exposure time (s) with **BinX=4 and BinY=X** for 4x4 binning
- Use **"loop"** exposures of ~0.1s, which are sufficient for light (but not for neutrons)

**On the "Display" tab:**

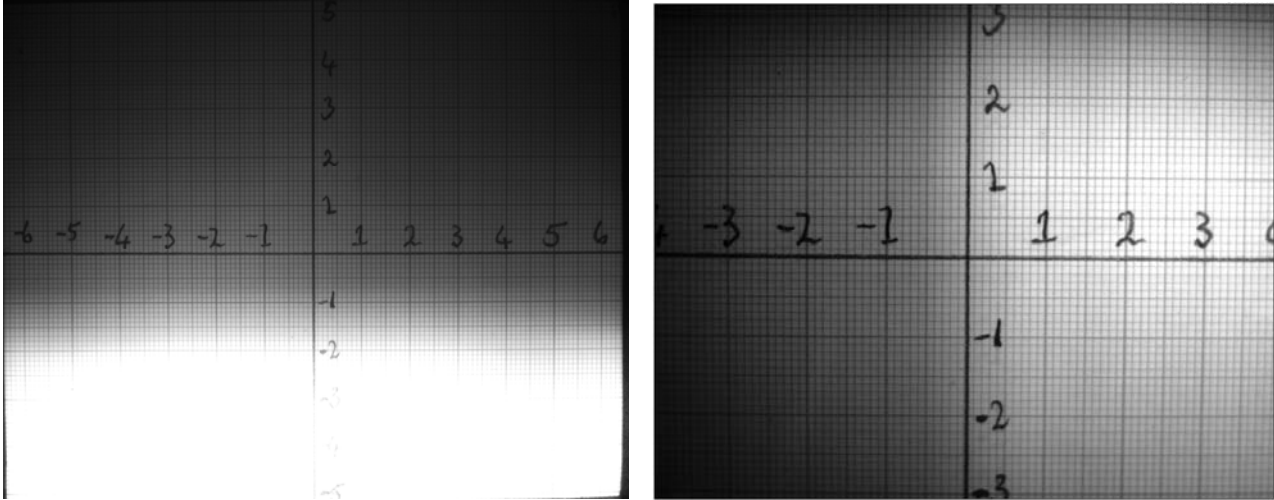
- Check the **"Auto stretch"** option to select the best 8-bits out of the 16-bits. Note that **scintillator afterglow may be seen for some minutes after exposure to light.**
- **"Zoom"** (or the wheel mouse button) zooms the display window

**On the "Cooler" tab:**

- Set the temperature to -20°C to reduce noise when collecting neutron images
- If the CCD is cold, click **"Warm up"** and wait a few minutes before disconnecting power

## Very Low Intensity Operation

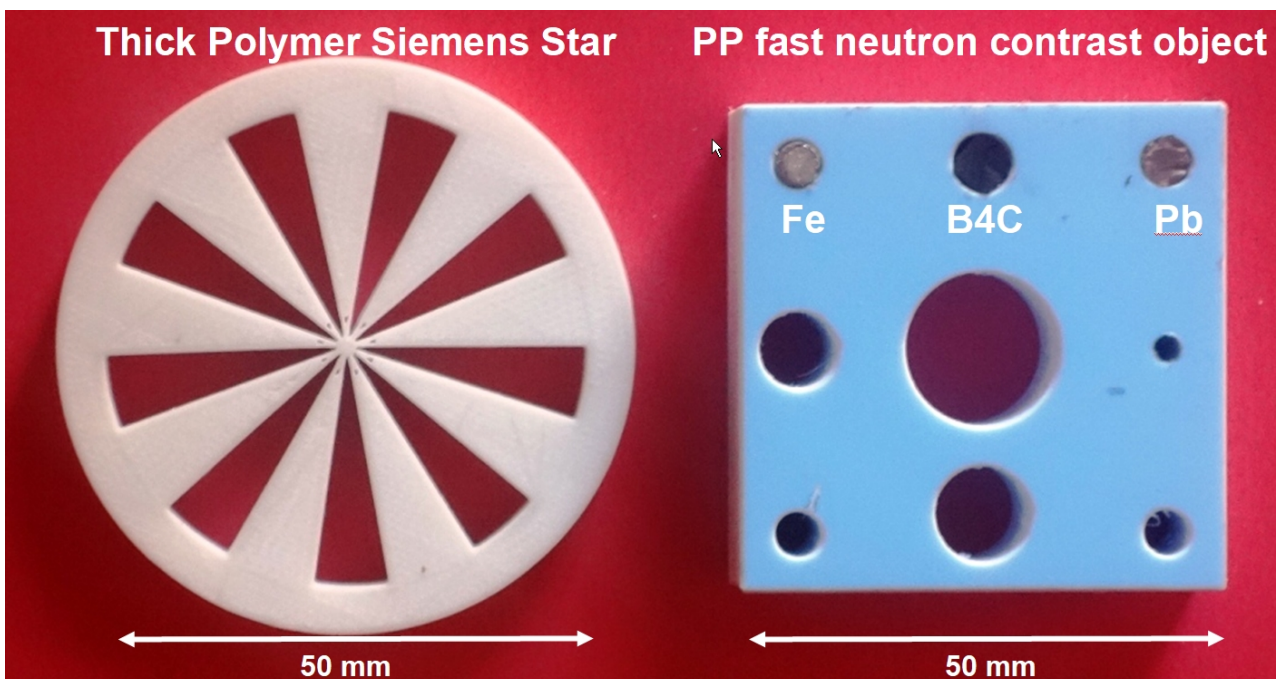
- If you get a "Cannot connect" error, try a different USB socket and/or unplug CCD power
- With the 145mm front-end box, the FOV is 125x100mm, or 80x60mm without this extension
- The smaller FOV will give x2.5 the intensity (and higher optical resolution)
- 8x8 binning will give x64 the intensity and faster readout, but lower resolution to 360 $\mu$ m
- "Zoom" (and the wheel mouse button) zooms the size of the image display  
Zoom in and use 1x1 binning to fine focus the lens on a grid with light



**a) FOV 125x100mm with 145mm front-end    b) FOV 80x60mm without front-end (refocus)**  
Light falls unevenly on the focus screen when the lens trap is open, as in the above images

- "Auto Stretch" compresses the 16-bit range of intensities to 8-bits for display
- The "Display" panel controls what you see, but has no effect on what you collect
- Image display is for guidance; use ImageJ for noise filtering and image enhancement
- The CCD should be cooled to reduce noisy pixels, especially for long exposures
- The centre of the image may not correspond precisely to the centre of the window because the CCD chip is not centred to better than 0.5mm in its housing
- After exposure to light, the scintillator will glow in the dark for >1 hour

## Special Fast Neutron Test Samples



## Tomography

For tomography you can collect a series of images, calling a script to rotate the sample after each image by using camera/sequencer. In this example we take 360 2x2 binned exposures of 4s (with no filter), writing individual files to "MyFile???.FITS" then executing script "orient.vbs" and waiting 5 seconds before starting the next exposure. You can substitute any application for "orient.vbs".

Enabled	Exposure (sec)	Binning	Filter Pos	File Suffix	System Command
<input checked="" type="checkbox"/>	4	2x2	0	MyFile	C:\VBScripts\orient.vbs
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		
<input type="checkbox"/>	1	1x1	0		

Sequence repeat mode: Lines (1,1... 2,2... 3,3...) Repeat count: 360

Delay between exposures: 5 Delay before start: 0

Buttons: Load settings, Save settings, Run, Close

For tomography, a precision sample turntable is needed to rotate the sample in increments of eg 0.5 degree between images. For samples of up to 30 Kg, we recommend the [Newport Micro-Controle URS turntables](#) which start at ~€2500, together with the [SMC100PP](#) motor controller (~€650) and [SMC-PS80](#) power supply (~€93) and [SMC-USB](#) USB interface(~€63). For high loads, the [RV120BPP](#), a smaller version of the [RV350BPP](#) used at ILL, is recommended. The Newport turntable is controlled by COM port scripts eg using [PuTTY](#)'s Plink command. A system file **orient.bat** is used to pass a file **commands.bat** to the turntable to **Position Relative 0.5** degrees.

orient.bat: `C:\commands.bat | Plink -v -serial COM4 -sercfg 57600,8,n,1,N`

commands.bat: `echo 1PR0.5 , timeout /t 1 /nobreak >nul 2>&1 , taskkill /f /IM Plink.exe , exit`

Plink opens port COM4 and pipes commands such as 1PR0.5 to 1 Position Relative 0.5°. waiting 1s before killing Plink, which will be restarted after the next camera acquisition. But first **open the SMC100 Software, click "Initialize"** so the controller light turns blue (ready state)

[ImageJ for ASCOM](#). is also suitable for tomography, Laue diffraction and very low-flux acquisitions.

## LabView and Artemis Software Development Kit (SDK)

The camera can also be controlled using [LabView](#), National Instruments' graphical programming environment for instrument control. You can download a [free time-limited version](#) if you want to control our camera together with other instruments. Excellent [LabView on-line tutorials](#) are available, as are a set of [simple LabView programs](#) (\*.vi files) to control the high resolution camera. Note that you also need the [LabView Vision Development Module](#), but you can download a free evaluation version.

We cannot provide support for LabView, for which you must rely on National Instruments or the NI user group, which has posted example files for Artemis cameras. One of our clients used a simple LabView application to control his sample turntable, and then used the ArtemisCapture/sequencer to call that Labview routine after each image acquisition.

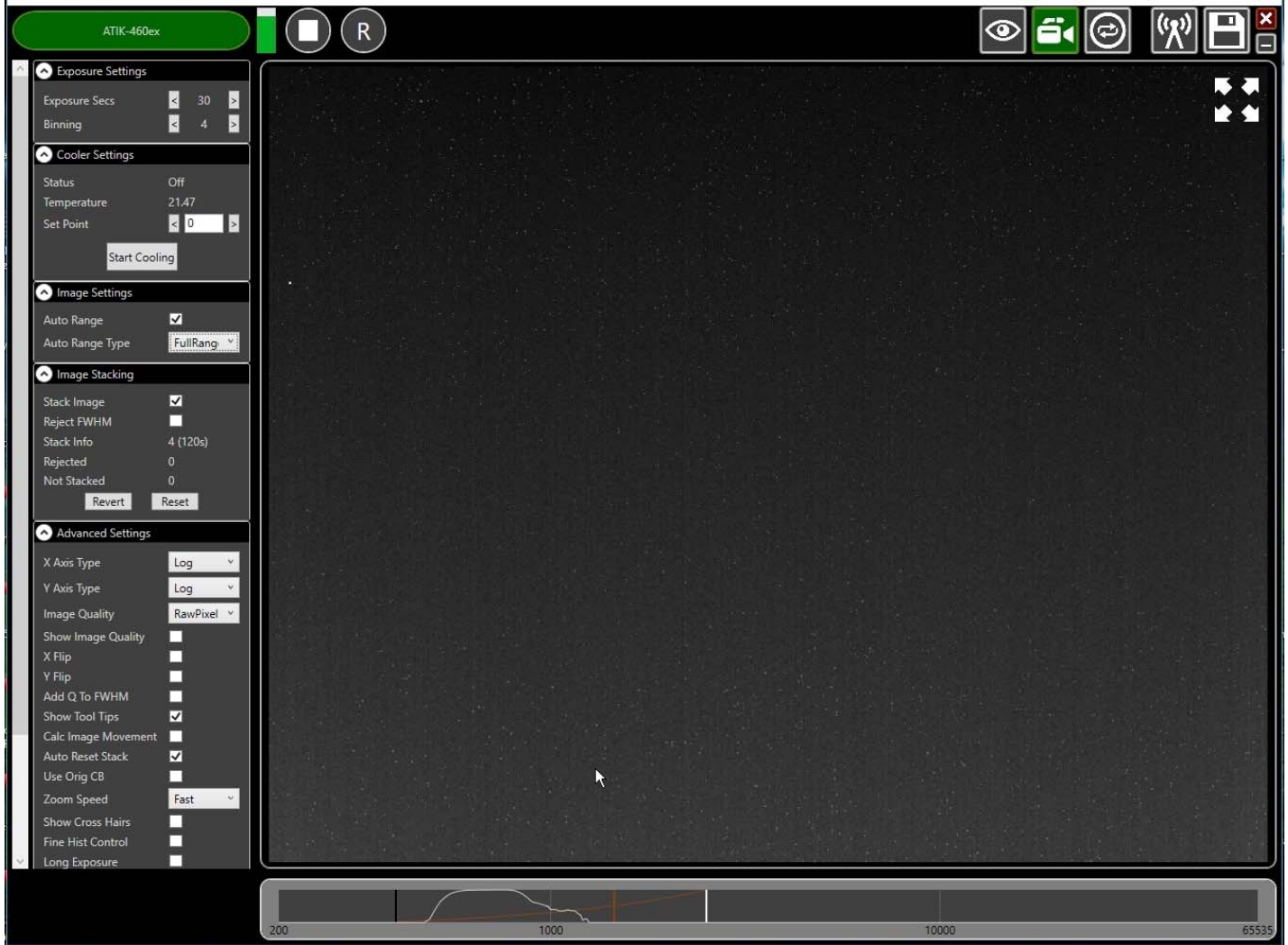
The Artemis SDK Software Development Kit contains C++ support and example files to allow you to develop your own camera acquisition code.

# Camera Control and Image Acquisition with Nebulosity

You can also use the [PHD](#) application for simple real-time image capture with the Hi-res camera (without cooling), or the [Nebulosity3](#) application, with either the Atik/Artemis driver or the ASCOM driver. These applications are also available for macintosh systems.

## Sequential Image Stacking with Artemis Infinity

The Artemis Infinity software, which works for all Atik high resolution cameras, can be installed with the [Atik core software](#); it can collect a series of short exposures, adding them together in real time. You can then **see how a long exposure is progressing**.



- Double-click the top bar to expand/contract the window.
- If connected, the camera name is shown in green
- Set the exposure time and binning (to 30s and x4 for the Laue camera)
- **Advanced Settings: Uncheck "Calc.Image Movement" & Check "Long Exposures"**
- Select the "video camera" icon on the top right to enable stacking
- In the "Image Stacking" dialogue that appears on the left **Uncheck "Reject FWHM"**
- The green triangle starts exposures, turning into a white square to stop exposures
- The "Stack Info" shows the number of images averaged (and the total exposure)
- The bar at the bottom controls the image display range
- Check "Auto Range" in the "Image Settings" and eg "FullRangeMinus"
- Otherwise, drag the vertical markers to bracket the display intensity range
- Noise is evident because we didn't cool. Set Temperature to 5C in "Cooler Settings"
- **If the camera is being cooled, click "Warm Up" before disconnecting power**

For the latest information, please check our web site <http://neutronoptics.com/atik.html>