# Assembly of the NeutronOptics Imaging Camera

The NeutronOptics Imaging Camera is shipped partly assembled because of the fragile nature of some components, such as the mirror and the CCD. These components are designed to be fitted quickly and easily by the end-user, and instructions are attached to the camera itself. This section illustrates and expands on those assembly instructions. The illustrations below show this L-shaped camera complete with the CCD and its $B_4C$/Pb protection on top, with the imaging box containing the scintillator in front of the interior mirror at the bottom.

**Some photos show slightly different versions of this camera**



0.2mm scintillator (Sealed)
Remove white plastic film before use

# Installing the front-surfaced mirror

1.  Place the foot of the mirror against the labelled $B_4C$ ledge on the camera back
2.  The plastic protected face with its instruction label must be on top
3.  Push the top of the mirror into the top labelled $B_4C$ holder
4.  When the camera assembly is complete, peel off the protective film
5.  The front aluminised face is protected by a transparent SiO layer for 95% reflectivity
6.  Do not touch or dirty the surface. If necessary, clean gently with window cleaner
8.  If necessary, use cyanolite glue spots for security, or glue a $B_4C$ strip to hold the mirror



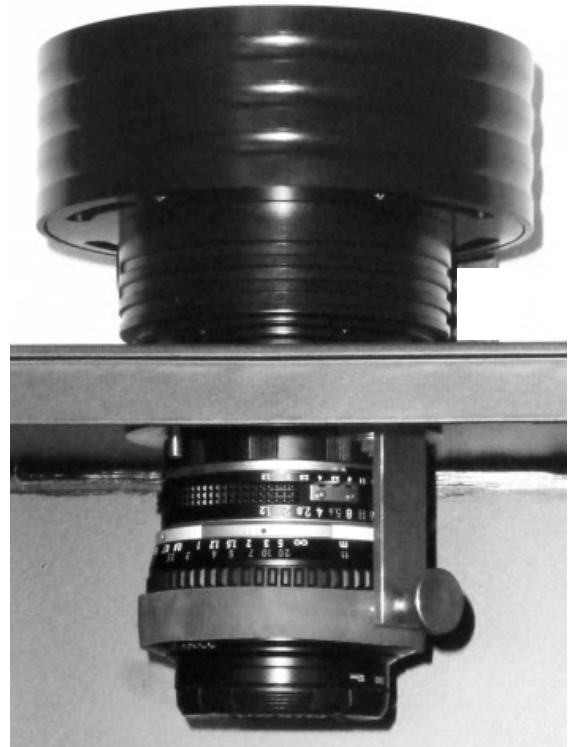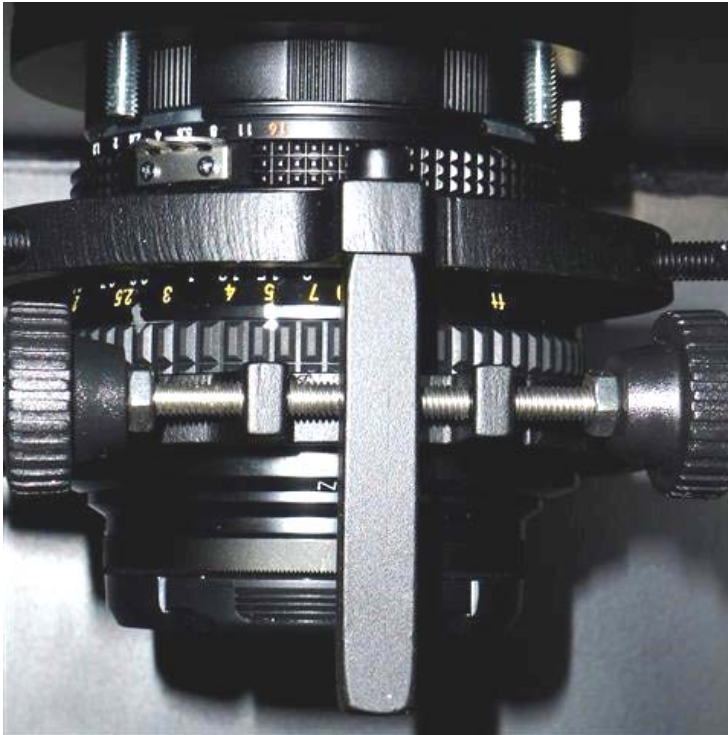# Installing the CCD and its $B_4C$/Pb protection

1.  Screw the CCD unit to the 42mm sleeve on the top of the main camera box
    Take care not to damage the fine screw threads
    The Lens-CCD distance is factory preset to ~46mm
    Loosen the "lock-unlock" ring to adjust the CCD distance & orientation
2.  Adjust the orientation of the CCD around its axis and lock it with the "lock-unlock" ring
3.  Bolt on the Pb/$B_4C$ protection to cover the CCD

# Adjusting the Nikon lens focus

1.  Manual focussing must be done with light, not in the neutron beam
2.  Place a paper grid over the scintillator plate being careful not to touch it
3.  Slide the scintillator front-end box onto the main camera box
4.  Set the nominal focal distance on the lens to 1-3m depending on the CCD position
5.  Connect the CCD cables and loop expose ~0.01s with f/1.2 and 4x4 binning
    4x4 binning is used to speed up image downloads (see operating instructions below)
7.  Clamp the focus ring with the screw clamp (there are two different models)
8.  Remove the focusing grid & close the box
9.  Check that it is light-tight for a long exposure. Note that the camera is very sensitive and **scintillator afterglow may be seen for some minutes after exposure to light.**

# Handling the scintillator

The front plate is aluminium for neutrons or carbon fibre for x-rays (very strong with 70% transmission for Cu-Ka at 8keV).The aluminium scintillator plate may be protected by a white plastic film, which must be removed. Do not touch the scintillator surface inside the box to avoid scratches or dirt.

0.2mm scintillator (Sealed)
Remove white plastic film before use

# Operation of the NeutronOptics Imaging Camera

The NeutronOptics 200x200mm imaging camera uses a 2048x2048 pixel CCD to provide 100 µM resolution. This large CCD also makes the camera more efficient, since big pixels collect more light. A large Nikkor f/1.2 50mm lens is used to maximise the scintillator light at the CCD, which is read out to 16-bit resolution to provide a high dynamic range. And the CCD is cooled to allow long exposures Be sure to protect this expensive CCD from radiation, which damages all electronic components.



0.2mm scintillator (Sealed)
Remove white plastic film before use

- **Neutron Scintillator:** RC-TriTec high resolution Li$^6$F/ZnS
- **X-ray Scintillator:** CAWO OG-16 fastest x-ray scintillator
- **Optics:** Nikkor 50mm f/1.2, the brightest FX Nikon lens
- **CCD Sensor:** Interline Kodak KAI04022
- **Chip size:** 15.15 × 15.15 mm, diagonal 21 mm (Type 4/3")
- **Resolution:** 2048x2048 (fewer pixels mean bigger pixels)
- **Pixel Size:** 7.4 x 7.4 µM (bigger pixels collect more light)
- **Binning:** from 2x2 to 8x8 (improved intensity and read-out )
- **High sensitivity** (QE>55% at 500-600nm), low smear
- **Low dark current** (<0.5 nA/cm$^3$), excellent anti-blooming
- **Full well capacity:** 40,000 electrons (large dynamic range)
- **ADC:** 16 bit grey scale image
- **Readout Noise:** 11 e- rms
- **Readout Time:** ~1s (preview) or ~6s (full 16-bit image)
- **Interface:** USB 2.0 High Speed with 10-20m USB cables
- **Power:** 12v DC 0.8A, to EU, UK, US/Japan, AU/CN standards
- **Maximum Exposure Length:** Unlimited
- **Minimum Exposure Length:** 1/1000s (1s at full resolution)
- **Cooling:** 1- or 2-stage Peltier with max ΔT=-33°C or -40°C
- **CCD Unit:** 120mm diameter, 78mm height, 990g weight
- **SDK:** C++, VB Wrapper, .net Wrapper, ImageJ, LabView

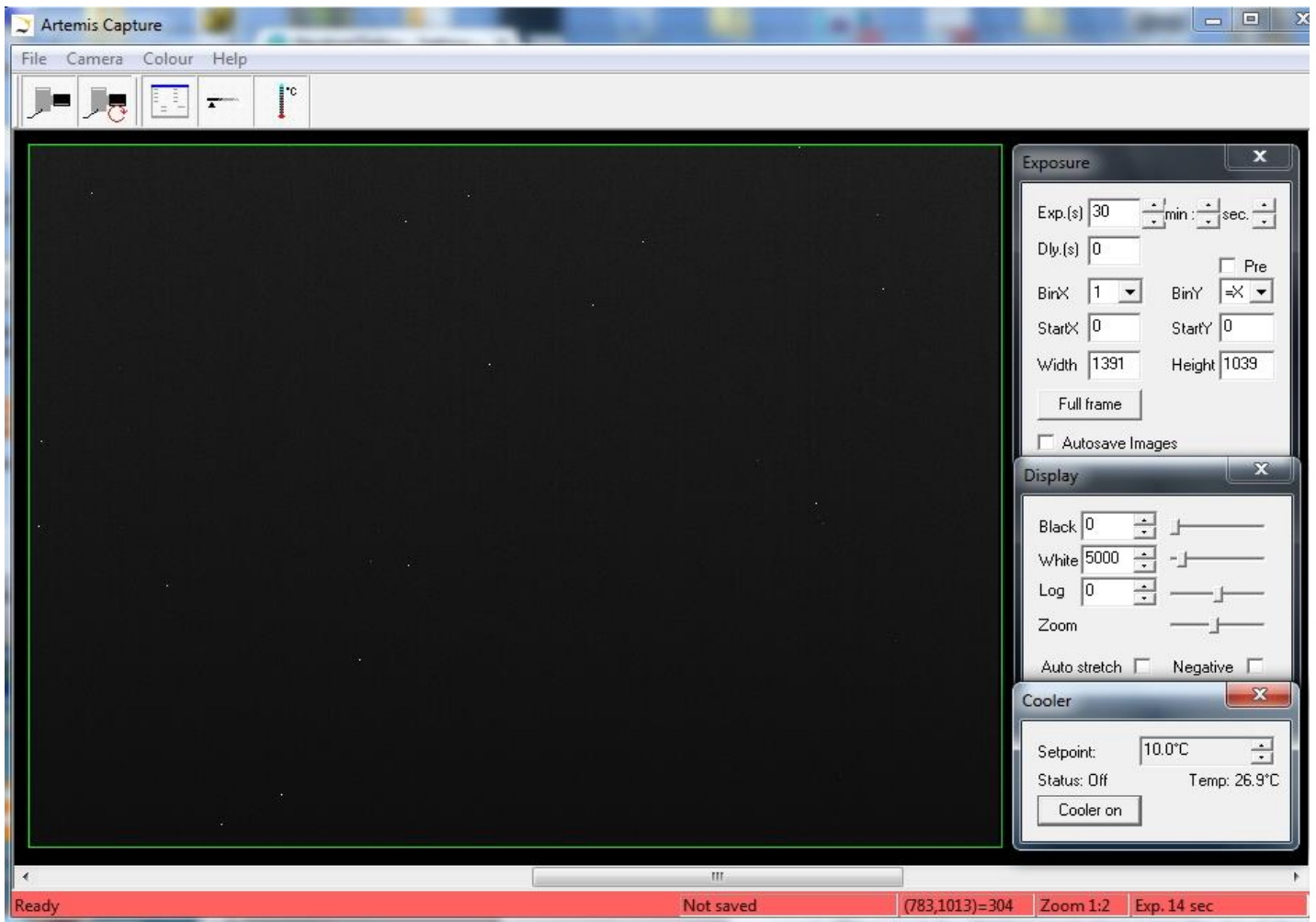## Installing the Driver and Artemis Capture software

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

10.     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
- Check the **"Pre"** box to reduce readout time at the cost of **greater readout noise**
- Select StartX, StartY, Width, Height as 750, 750, 500, 500 to reduce readout time
- 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

# Manual Lens Focussing and Macro Imaging

**Focussing is with light, not neutrons.** Place graph paper immediately in front of the scintillator, taking care not to dirty the scintillator surface. Slide the scintillator box onto the camera and open the lens door to allow light to enter. With the CCD near its closest position to the camera box, adjust focus for a small 500x500 pixel selected area, eventually with binning to speed up downloads. When focussing is complete, collect a "full frame" to check the FOV. Clamp the lens focus, remove the graph paper and seal the camera.

**With macro imaging you can obtain a smaller FOV** by using the short front end. The minimum, focus distance of the 50mm lens is 500mm, but you can focus closer by increasing the distance between the lens and the CCD. You need an extra ~3mm to focus at 350mm, which can be obtained by simply unscrewing the CCD 4 turns and clamping it 3mm further from the camera box. (Otherwise you could use a "macro-ring" spacer immediately underneath the lens mount inside the camera).

# Hints on getting Optimal Performance

- **If the image is black, reduce the exposure to avoid saturation.**
- The exposure time depends of course on the intensity of your beam
- 2x2 binning will give x4 the intensity and faster readout, but halve resolution
- You can also limit readout to a "sub-frame" region of the full image
- The "Display" panel controls what you see, but has no effect on what you collect
- "Zoom" (and the wheel mouse button) zooms the size of the image display
- "Auto Stretch" compresses the 16-bit range of intensities to 8-bits for display
- But usually you will want to select the black and white display limits manually
- Image display is for guidance. Open the image with ImageJ for measurement
- The CCD can be cooled to reduce noisy pixels. You can also use ImageJ filters
- Fogging may occur if you cool below $0^{o}C$ (the CCD chamber contains a desiccant)
- The desiccant can be replaced by removing the large screw on the camera shaft

Cooling becomes particularly important for very long exposures to greatly reduce the number isolated hot pixels. Those remaining can easily be removed with the ImageJ Despeckle filter.

You can also use our custom PHD application for simple real-time image capture with the Hi-res camera (without cooling), or the demo Nebulosity3 application, with either the Atik/Artemis driver or the ASCOM driver.

# Occasional Problems with camera operation

- Be patient when you first launch ArtemisCapture. Wait for it to load and detect the camera.
- If ArtemisCapture complains that it cannot connect to the camera, and the cables are in place, a background copy of the application may already be connected. Unplug the power to the camera - this will close any open connections - then try again.
- Check that an ArtemisCCD device is connected in the USB controller list in the Windows Device Manager, which is accessed by right-clicking MyComputer.
- Try deleting the ArtemisCapture.ini file from the C:\Windows folder to reset Artemis Capture.
- Try a different USB port, waiting for the driver to be found and re-installed.
- USB ports can sometimes become un-responsive. Shut down the computer and remove the computer's power cable for a few seconds. Then re-connect everything and reboot.
- If all else fails, try using a different computer.
- **A black image may simply mean the CCD is over-exposed. Reduce the exposure time.**
- The centre of the image doesn't correspond to the centre of the window because the CCD chip is not centred to better than 0.5mm in its housing
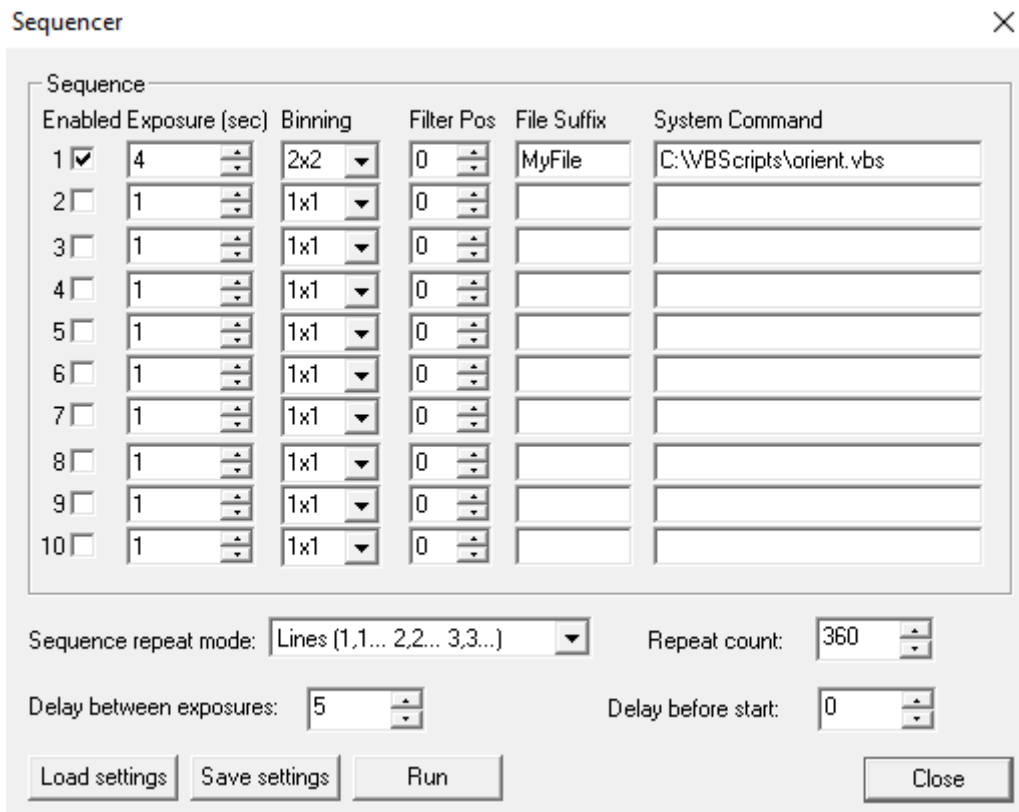
# Image Treatment with ImageJ

ImageJ is recommended for image analysis. ImageJ will open the 16-bit raw FITS files produced by Artemis Capture, remove noise, modify contrast and other properties, and save them in various formats. More importantly, it will allow you to measure intensity profiles and display your data in ways that will make it more meaningful.

A complete ImageJ installation is included on the NeutronOptics software CD under "Extras". Just copy the ImageJ folder to your C: disk and launch ImageJ to set defaults and update ImageJ.

# Tomography, Laue Diffraction and ImageJ for ASCOM

**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 type of script or application for "orient.vbs". See also ImageJ-for-ASCOM.



ImageJ for ASCOM. is also suitable for tomography, Laue diffraction and very low-flux acquisitions. The acquired images are opened directly in ImageJ, and you can easily modify the interface by extending the ImageJ scripts. At the end of each image acquisition, a Windows routine Orient.vbs is launched (if it exists) to eventually re-orient the sample. You can even simultaneously acquire images from two cameras and stitch them together.

# 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 Developement 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 Developement Kit contains C++ support and example files to allow you to develope 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.

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