The NeutronOptics 1:1 Macro Camera

The NeutronOptics Macro camera uses a high resolution macro lens to obtain a 1:1 object : image magnification, so the FOV is equal to the size of the CCD chip, and the nominal resolution equal to the size of its pixels. It can take any Nikon F-mount CCD camera, or any C-mount camera with the supplied adapter, shown on top.

It is shown here without a CCD camera, but with our Sony 1" CCD (below) a FOV of 12.5x10.0mm is obtained, with a nominal resolution of 5 µM, or a FOV of 37x26mm with our 35mm full-frame KAI11002 CCD camera. Note that real resolution will be limited by the scintillator and beam collimation to much less than that.

This lens uses a unique focus clutch. Pulling the 75mm focus ring towards the CCD engages manual focus; pushing it away locks focus. Otherwise, a mechanical lock (silver) can be clamped to the focus ring and focus adjusted and locked using the removable thumbscrews.

The aperture is set at the top of the lens (to f/2.8), and the lens barrel extends for near focus (30mm). A machined 50mm cylinder is screwed to the end of the lens, and this cylinder is either screwed directly to the 90-degree mirror, or slides into a second black cylinder which screws into the mirror unit. The Lens lock then clamps the mirror assembly to the lens, while allowing it to be rotated to align with the camera. The c-mount adapter also allows camera rotation.

The x-ray or neutron scintillator can be changed simply by unscrewing the 40mm diameter window holder; a 0.5mm carbon window is used for x-rays. 40mm plastic (powder) X-ray or neutron scintillator disks are supplied.

The complete camera can be suspended below the CCD unit, whose cables must not be allowed to drag on the assembly.

Assembling NeutronOptics VS60 Macro Camera

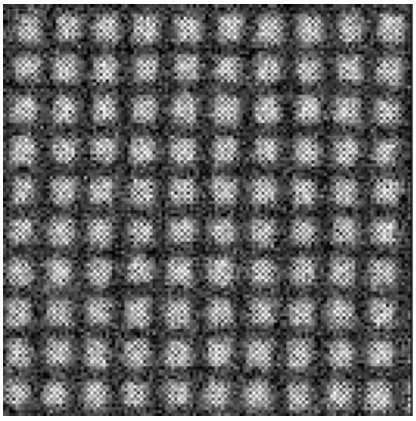
- The VS60 macro camera is shipped disassembled to its component parts for safe shipping
- The camera unit can be suspended using the pair of 1/4" bolts on its sides
- The C-mount adapter screws clockwise into the VS60 camera unit. Don't touch the CCD
- The 100mm Tokina macro lens screws anti-clockwise onto the Nikon F-mount bayonet of the adapter
- The 90-degree mirror unit with its sliver 1:1 tube screws into the front of the lens. Don't touch the glass
- *Eventually this tube can be inserted into the black tube (first photo) to increase the distance and FOV*
- Set f/2.8 and close focus (0.3m) for the lens (near maximum extension)
- Focus on the 50-micron wire grid with room light (paper over window). Lock by pulling the focus ring down
- *Eventually focus lock clamps (first photo) can be used*
- Replace the wire grid with a scintillator and cover the scintillator with the carbon fibre C-window (below)
- Highest resolution is obtained with fine focus sources and objects close to the scintillator window
- **Thin scintillators for highest resolution can be used with the black surface outmost & no C-window**

NeutronOptics VS60 Macro Camera Operation

Fast high resolution thermo-electrically cooled Sony 2750x2200 pixel VS60 CCD unit

- **X-ray Scintillator:** Interchangeable fast, fine x-ray scintillator
- **Neutron Scintillator:** Interchangeable high resolution neutron scintillator
- **Optics:** Interchangeable high resolution 100mm f/2.8 macro 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
- **Pixel Size:** 4.54x4.54 µM (larger pixels & micro-lenses for 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 ΔT = -35°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

The optical resolution of the 1:1 macro camera is <10 micron with the 4.54 x 4.54 micron pixels of this VS60 CCD unit. The image opposite shows details of a 50 micron wire grid imaged with light.



X-ray resolution will be lower, and depend on the scintillator, beam collimation and distance between the object and scintillator. Agfa-Gevaert (CAWO) OG2 and OG16 powder scintillators as supplied with the camera should be capable of ~50 micron resolution, but for 10-20 micron resolution thin YAG:Ce or LuAG:Ce single crystal scintillators should be purchased directly from CRYTUR.

Alternative lower cost cooled CCD units

- **Sensor Type:** Sony ICX825ALA or ICX694ALG
- **Image size:** Diagonal 11mm (Type 2/3") or 16mm (type 1")
- **Resolution:** 1392x1040 or 2759 x 2200
- **Pixel Size:** 6.45x6.45 µM or 4.54 x 4.54 µM
- **Binning:** from 2x2 to 8x8 (improved intensity and read-out)
- **High sensitivity** (QE>75% at 500-600nm), low smear
- **Low dark current** 0.003@-10 °C, excellent anti-blooming
- **Full well capacity:** 20,000 or 40,000 electrons
- **ADC:** 16 bit grey scale image, optional filtering and distortion
- **Readout Noise:** 4 e- typical (slower readout = less noise)
- **Readout Time:** 1-3s
- **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:** 0.001 seconds
- **Cooling:** Thermoelectric set point with max ΔT=-27°C
- **CCD Unit:** 60mm diameter, 122mm length, 400g weight
- **Lens Coupling:** T2-mount, C-mount, F-mount
- **SDK:** C++, VB Wrapper, .net Wrapper, ImageJ, LabView drivers

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)

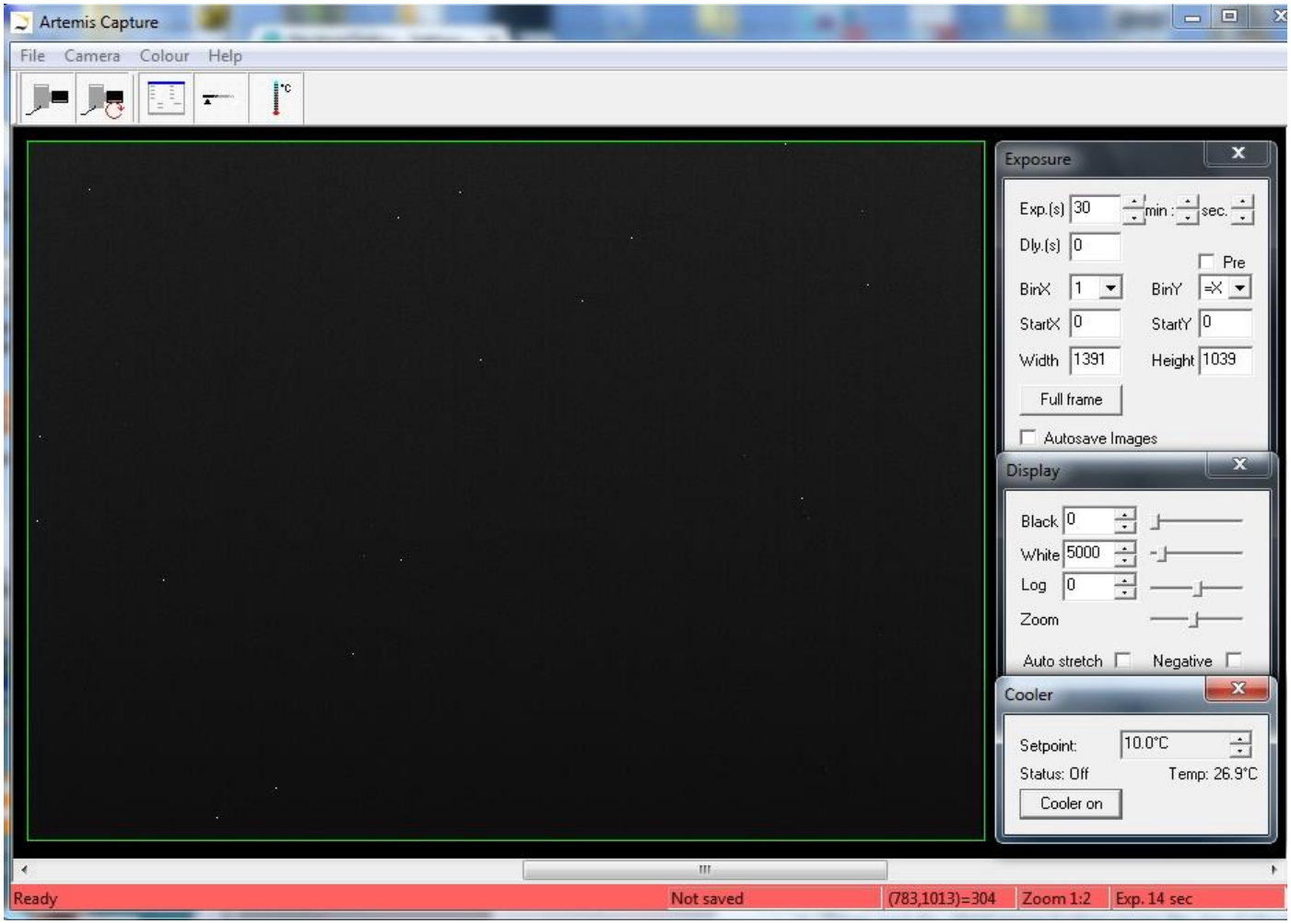
If the driver is not found automatically, try manual installation:

- 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, "Camera" menu is to connect 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.

IMPORTANT: Zoom out to see the green outline of the full CCD.



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

- Set exposure time (s) with **BinX=4 and BinY=X** for 4x4 binning and **Dly(s)=0** delay
- Select a **subframe** "Width", "Height", "StartX" & "StartY" 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 -15^{o}C to reduce noise when collecting long neutron images
- If the CCD is cold, click **"Warm up"** and wait a few minutes before disconnecting power

Hints on getting Optimal Performance

- 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 speed up readout by limiting it to a "sub-frame" 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, both 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 get into a state where they become un-responsive. Shut down the computer and remove the computer's power cable. Then re-connect everything and reboot.
- If all else fails, try using a different computer.

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.

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".

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 **P**osition **R**elative **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.

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 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 develop your own camera acquisition code.

Latest version: http://neutronoptics.com/downloads/Manual-NeutronOptics-Macro-Camera.pdf