NeutronOptics 125x100mm CMOS Laue Camera

We have developed various Laue crystal alignment cameras for x-rays, and similar cameras can be used with a neutron beam. They allow rapid crystal alignment, and can also be used for hands-on teaching of crystallography. A finely collimated white beam produces a number of "Bragg spots" from a single crystal, and by measuring the positions of these spots the crystal orientation is determined.

Greater precision is obtained with backscattering, but the intensities are weaker, especially for x-rays because of the scattering "form-factor". A classic bench-top x-ray generator with a spot size of ~1mm and power of 30-50 kV and 30-50 mA is required. The photo shows our new 125x100mm CMOS camera, the same size, but x6 more efficient than our old 1-CCD Laue camera for the same price.


Our old 1" Sony ICX694 12.5x10mm chip, with an f/1.4 lens, is replaced by our 24x16mm APS-C IMX571 detector with a faster f/0.95 lens. The area of the APS-C chip is x3 larger, and the lens aperture is x2 greater, so **the total gain in efficiency is x6** !

The photo shows our compact APS-C Laue camera, which is the same size and price as our old 1-CCD Laue camera.

- **Camera dimensions:** 222x146x90mm
- **Field-Of-View:** 125x100 mm
- **Optical Aperture:** f/0.95
- **Sensor:** Sony CMOS IMX571
- **Chip size:** 23.5x15.7mm (APS-C)
- **Resolution:** 6248x4176
- **Pixel Size:** 3.75 x 3.75 µM
- **Binning:** from 2x2 to 8x8
- **High sensitivity:** (QE~90%)
- **Low dark current:** 0.003@-10 °C
- **Full well capacity:** 50,000 electrons
- **ADC:** 16 bit grey scale image
- **Readout Noise:** 3 e- typical
- **Readout Time:** <1s
- **Interface:** USB 3.0 with 10-20m cables
- **Power:** 12v DC to local standards
- **Cooling:** Thermoelectric: ΔT=-35°C
- **Typical Laue Exposure Time:** 30-60s

W pattern in 30s on a 2kW generator at ~35keV
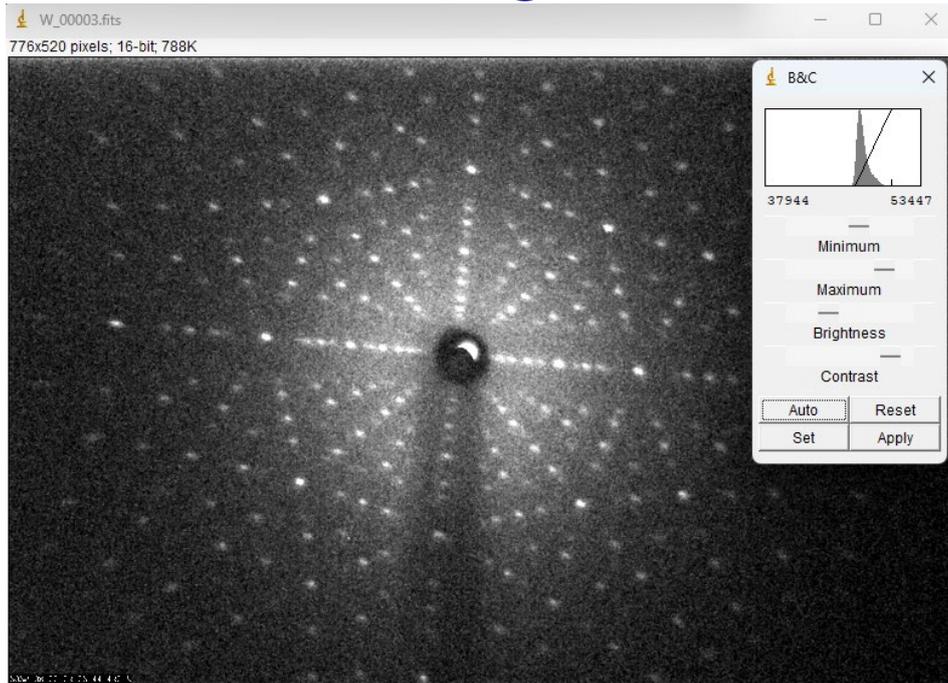
NeutronOptics 180x120mm CMOS Laue Camera

This large 1-CMOS Laue camera is designed to **replace our old 2-CCD Laue camera**. By using a larger APS-C 24x16mm CMOS detector instead of two 12.5x10mm CCDs, we increase the total detector area (efficiency) by over 50% allowing a larger FOV for similar exposure times (1-2 minutes). The efficiency is further improved by using a modern f/0.95 lens instead of a pair of f/1.4 lenses.

This new camera with higher efficiency and simpler operation is also less expensive than the old 2-CCD camera, but because of the larger FOV with the same detector, it is only 50% as efficient as the smaller 125x100mm CMOS camera, which should be preferred for most applications
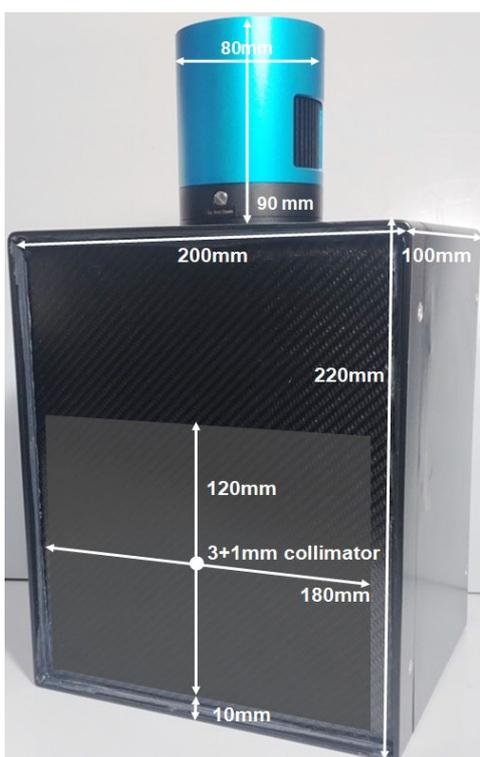
- **Camera dimensions:** 220x200x100mm
- **Field-Of-View:** 180x120 mm
- **Optical Aperture:** f/0.95
- **Sensor:** Sony CMOS IMX571
- **Chip size:** 23.5x15.7mm (APS-C)
- **Resolution:** 6248x4176
- **Pixel Size:** 3.75 x 3.75 µM
- **Binning:** from 2x2 to 8x8
- **High sensitivity:** (QE~90%)
- **Low dark current:** 0.003@-10 °C
- **Full well capacity:** 50,000 electrons
- **ADC:** 16 bit grey scale image
- **Readout Noise:** 3 e- typical
- **Readout Time:** <1s
- **Interface:** USB 3.0 with 10-20m cables
- **Power:** 12v DC to local standards
- **Cooling:** Thermoelectric: ΔT=-35°C
- **Typical Laue Exposure Time:** 1-2 min

Installing the NeutronOptics Laue Camera on the x-ray beam

The photos below show how **Prof. W. Donner and Dr L. Diop at the T.U. Darmstadt** converted a Huber Image Plate Laue camera (left) to use the NeutronOptics 1-CCD Laue camera (right). **The CMOS camera can be installed in the same way, since the detector box is the same size.**
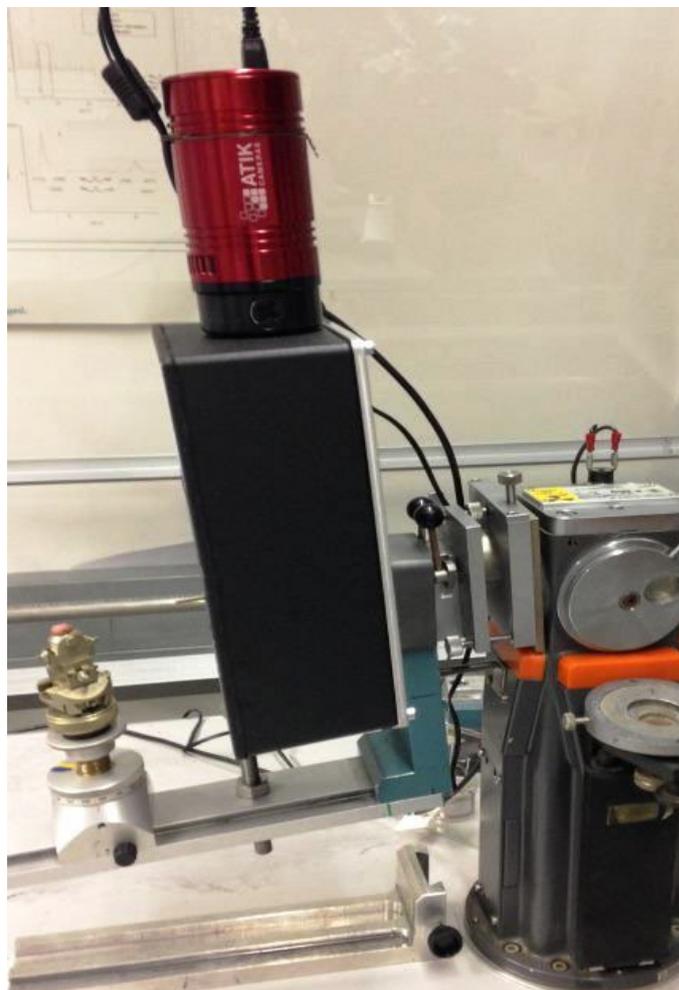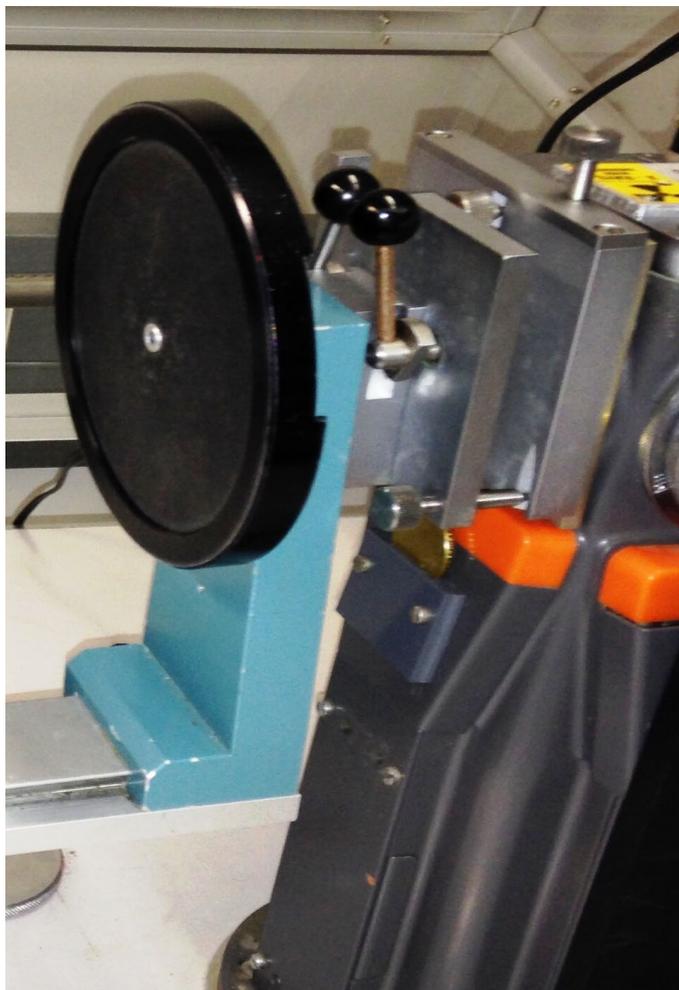
Left photo: The Huber IP camera is the circular disk mounted on a blue support on a guide rail. The collimator is locked and the beam shutter opened with the two black knobbed levers on the double-metal plates that form the Huber-800 alignment mechanism, which is mounted on a 1960's Philips X-ray generator. The screw at the top, and two at the bottom, adjust the height and tilt of the collimator.

Right photo: The Huber-800 unit is retained, together with the blue camera support, when the Huber IP camera is replaced by the 1-CCD camera. An additional support bolt on the rail under the bottom left supports the heavier camera. The new collimator is aligned in the Huber-800 mechanism for maximum intensity, and the camera is then bolted on using an aluminium plate and four M4 bolts.

Mount the camera as close to the source as possible using the 4mm bolt holes at the back; minor adjustments to position and orientation are necessary. Before inserting the 1mm collimator tube into the camera, check that it fits the source exit and allows no x-ray leakage. **You will need to make a small adapter** to take the 2mm collimator tube, depending on your source. The 1mm collimator slides into the 2mm tube, with the nose extending toward the crystal ~30mm from the window.

1mm Collimator nose

The collimator must be precisely aligned, and the source voltage and current set for maximum intensity through the collimator. The carbon fibre window & scintillator are not fragile. To remove collimator tubes, **pull them out from the back of the camera**, and insert them from the back. **The O-ring can be sealed** with a very small amount of black mastic or eventually black paint.

NeutronOptics APS-C CMOS Camera Operation

Install the ASI Camera Driver & Software for Windows, Linux or Macintosh

- Install the Windows camera driver toupcam.dll (x64)l from the DVD, or download it from
  https://www.touptek-astro.com/downloads?atfWidgetNav=box_win
- You can use **ToupView** to control the camera, but we recommend **SharpCap4**
- **ToupTekDshowAstro** provides alternative Dshow support
- If you want to develop your own software, download the **SDK** **zip** Software Development Kit
- You may want to install the **ASCOM Platform Driver** if you want to use **ImageJ-for-ASCOM**
- Do not update the camera firmware if you don't have problems with that already installed
- You can also read the **ToupTek** manuals, but these describe mainly astronomy and microscopy
- General **ToupTek software** for other computer systems can be downloaded from their web site
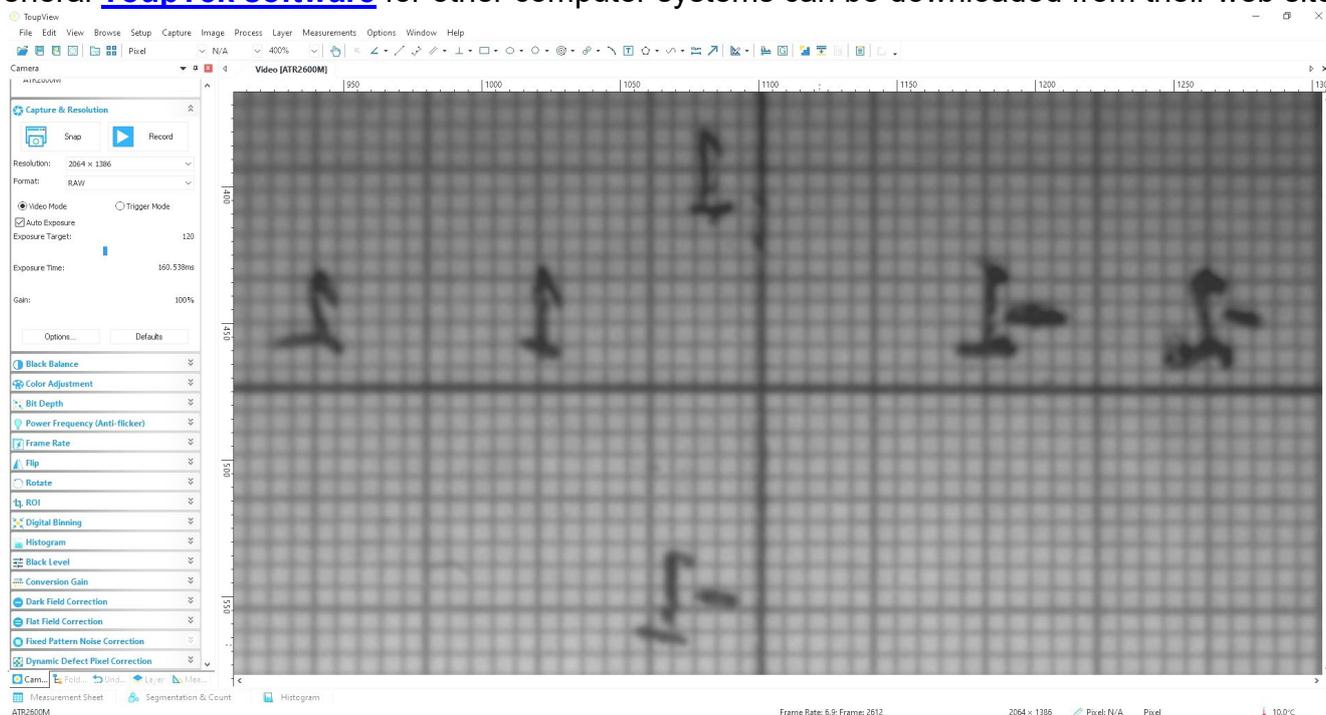

This screen capture of **ToupView** has been limited to 2064x1386 pixels to speed up the frame rate for focussing. Note that Raw 16-bit un-binned images have been selected and the exposure set to auto. The image shows a small area of the total FOV of millimetric graph paper taped over the scintillator, illuminated by light. **Do not attempt this with the CMOS Laue Camera.**

ToupView may be sufficient for simple beam monitoring, and is available for both Windows, MacOS and Linux computers, but Windows **SharpCap4** offers more features suitable for Laue diffraction. And our **ImageJ-for-ASCOM** interface allows you to program complex acquisitions within ImageJ.

Installing the Recommended SharpCap4 Viewer

Use SharpCap4 from the DVD or download it from https://www.sharpcap.co.uk/sharpcap/downloads SharpCap was designed for low-light imaging for astronomers, with more complete controls, including many you will not need for imaging. Prefer the 64-bit version for memory management.

The camera will be automatically recognised if it is plugged in, and you just need to choose it from the "Cameras" menu. A window will open with the image and camera controls on the right. You can arrange the order of controls by dragging the 3-line icon. An exhaustive SharpCap User Manual is available, but the instructions below may be sufficient.
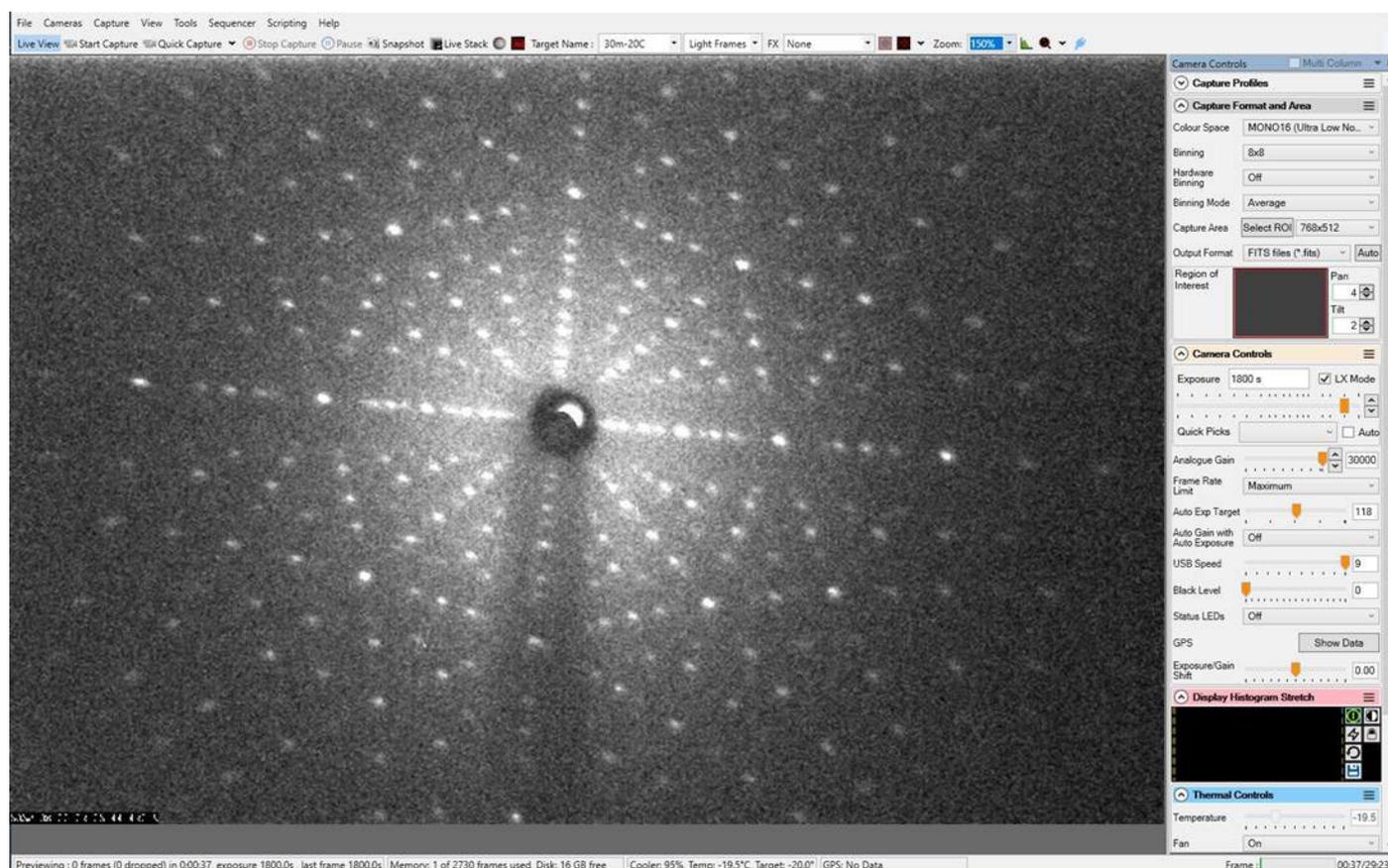
You don't need high resolution, so you can bin (sum not average) the detector pixels by up to 8x8 to increase intensity. Maximise the Analogue Gain, and drag the vertical dotted line in the Display Stretch Menu to the left to emphasise low intensities. Set the Temperature to -20C to minimise noise.

Set **"Capture Format"** to TIFF or FITS, Mono16 ultra low noise. Click "**Snapshot**" to save a single image frame. **FITS files can be opened** with **imageJ** and the **Windows Store QuickLook** with the **FitsViewer plugin**. Open FITS files with a text editor such as NotePad++ to read image parameters.

In menu **"File/Settings"** check auto connect and restore, with format AVI and FITS. Choose where and how files are saved. **Tip:** set a **"Default Profile"** to open with those settings on start-up.
The camera settings are in a hidden file called **_autosave (camera name).ini** which can be found in:
C:\Users\<your windows user name>\AppData\Roaming\SharpCap\CaptureProfiles
You can delete this file and it will be created again next time you exit SharpCap

If you do use SharpCap, consider paying £12 for a license https://store.astrosharp.co.uk/Store
You need a license if you want to use advanced features like scripting, useful for tomography.

Hints on getting Optimal Performance

- **Experiment thoroughly without radiation until you fully understand the camera controls**
- High Gain will multiply the intensity, but reduce the dynamic range
- Binning will multiply the intensity and speedup readout, but reduce optical resolution
- You can also limit readout to a "sub-frame" ROI region of the full image
- The "Display" panel controls what you see, but has no effect on what you collect
- Drag the vertical dashed line in the display panel to adjust the displayed intensity
- "Zoom" (and the wheel mouse button) zooms the size of the image display
- Image display is for guidance. Open the image with ImageJ for measurement
- The CMOS chip is cooled to reduce noisy pixels. You can also use ImageJ Despeckle filter
- The Window heater prevents fogging below 0°C (the CMOS chamber contains a desiccant)
- The centre of the image doesn't correspond precisely to the centre of the window

Cooling/Despeckling is important for very long exposures, where you may be using high Gain with weak sources. **Note that the camera is extremely sensitive to the tiniest light leak.**

Very Low-Light Laue Imaging with SharpCap

Colour Space	MONO16 (Ultra Low No...	**16-bit high dynamic images. 8-bit gives faster readout**
Binning	4x4	**Increase software binning up to 4x4 or 8x8 to increase signal**
Hardware Binning	Off	**Alternative hardware binning speeds up transfer**
Binning Mode	Sum	**Use "Sum" with software binning for very weak signals**
Capture Area	Select ROI 1556x1042	**A limited Region-Of-Interest or Binning will speed up transfer**
Output Format	FITS files (*.fits) Auto	**FITS or TIFF files allow 16-bit output (with imageJ or QuickView)**
Exposure 1800 s ☑ LX Mode		**LX mode is for long exposures (minutes)**
Quick Picks ☐ Auto		**Exposure times are not limited to Quick Picks**
Analogue Gain 30000		**Experiment with high gain at the expense of higher noise**

Image Treatment with ImageJ and Laue Pattern Indexing

ImageJ will open the 16-bit raw FITS files, filter noise, modify intensity/contrast, and save them in various formats. An ImageJ installation is included on the NeutronOptics software CD under "Extras". **Copy the ImageJ folder to your C: disk** and launch ImageJ to set defaults and update ImageJ.

You can use ImageJ's **"Process/Noise/Despeckle"** to filter out electronic noise and **"Process/ Subtract Background"** with "rolling ball radius 25-50 to remove some of the diffuse backround. You might also try ImageJ's **"Process/FFT/Bandpass filter"** to filter out large structures of 30+ pixels and small structures of 3+ pixels, with "autoscale" and "saturate" to emphasise the peaks.

A more powerful macro routine can be downloaded to **ImageJ\macros\toolsets** then loaded by clicking on the **red ">>"** menu item on the far right and selecting "Subtract Diffuse Bkgd". This will install the command **"Plugins/Macros/Subtract Diffuse Bkgd"**. The left image below shows a very poor image with isolated bright pixels and no obvious Laue pattern. The right image shows the astonishing effect of this macro command**.**
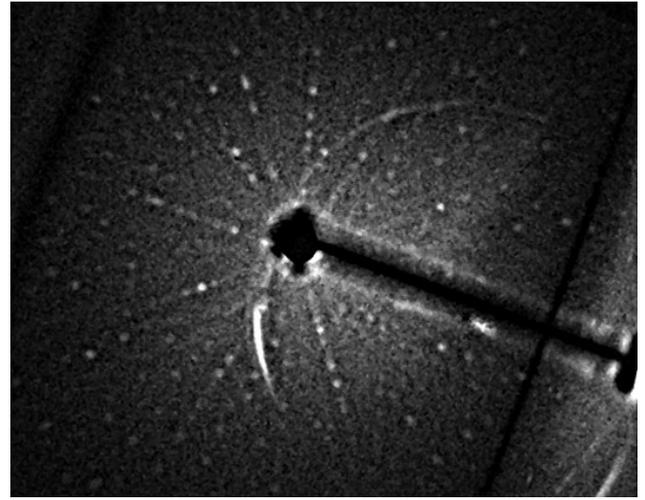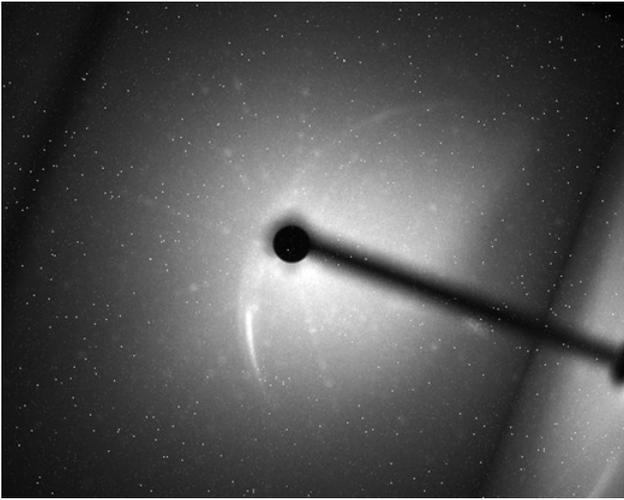
This organic material **is an extreme example** showing strong diffuse scattering that reduced by the "median filtering" macro written by M. Cammer as an alternative to the **Bandpass filter**.

Image Treatment with ImageJ and Laue Pattern Indexing

We recommend **OrientExpress** and the ambitious new **ESMERALDA Laue suite**, and the **Cologne Laue Indexing Program (CLIP)** is one of the best, along with the **QLaue Indexing Program**. Or try **WinLaue** to simply simulate Laue patterns to become familiar with the technique