

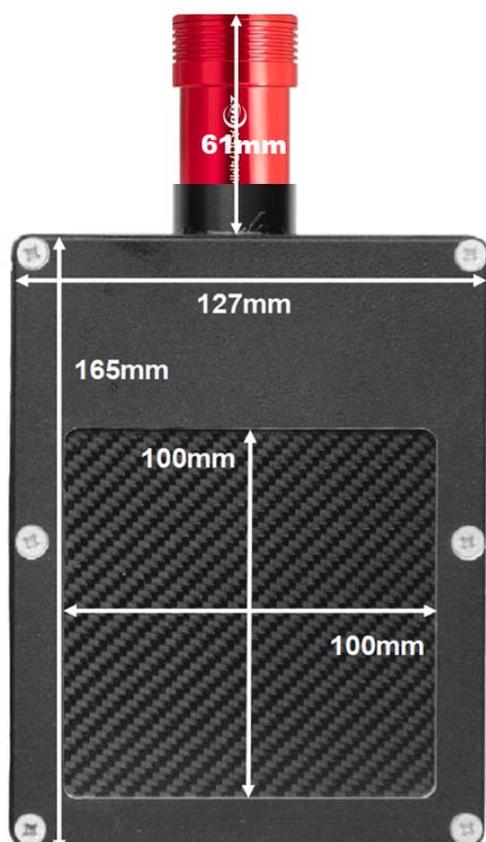


## Install the ASI Camera Driver & Software for Windows, Linux or Macintosh

- Launch the Windows camera driver [ZWO ASI Cameras driver Setup V3.23.exe](#) from the DVD  
Or download it from <https://www.zwoastro.com/software/> or use MacOS or Linux versions.  
The Linux software will even run on a [Live Persistent Linux MINT USB stick](#).
- You can use ASICap from [ASISudio](#) to control the camera, but we recommend [SharpCap4](#)
- If you want to develop your own software, download the [SDK](#) Software Development Kit
- Do not update the camera firmware if you don't have problems with that already installed
- [LabView demo software](#) is available for Windows
- You can also read the ZWO detector manuals, but these describe astronomical applications

## Compact CMOS Neutron and X-ray Alignment Cameras

The IMX174 is a faster frame-rate version of the IMX249, and currently [the best small Sony CMOS detector for low-light imaging](#). It is a relatively large sensor, with big pixels favouring light capture, with high Quantum Efficiency (QE) The USB2 ASI174mini camera is powered by a USB cable up to 25m long. The focus is preset for the 100x100mm camera, so just plug it in **after driver installation**. **Note** that only the USB-C socket is used on the camera; the other socket is for astronomical use.



The camera is shown opposite with a 0.5mm carbon fibre window for x-rays; an aluminium window is used for neutrons.

- **Sensor:** monochromatic Sony Pregius CMOS [IMX174](#)
- **Cooling:** not cooled
- **Image Area:** 11.25x7.03 mm (1/1.2")
- **CMOS Resolution:** 1920 x 1200 pixels
- **Optical Resolution:** ~85  $\mu\text{M}$  over 100x100 mm
- **CMOS Pixel Size:** 5.86 x 5.86  $\mu\text{M}$
- **Binning:** x1 or x2 in software
- **Region of Interest:** User selectable
- **Quantum efficiency:** >80%
- **Low dark current:** <1 e/s at ambient
- **Full well capacity:** 30,000 electrons without binning
- **High dynamic range**
- **ADC:** 12 bit grey scale, optional filtering and distortion
- **Readout Noise:** 7 e<sup>-</sup>
- **Frame rate:** 18 fps max, up to 200 fps for selected area
- **Interface:** USB High Speed with 10-20 M active cables
- **Min/Max Exposure Time:** 32 $\mu\text{s}$  - 300s
- **Power Supplied:** 5V via USB
- **Software:** Free SharpCap4, automatic acquisition

## Small High Resolution CMOS Neutron and X-ray Imaging cameras

This camera is based on our 1-CCD Laue camera, but uses a **cooled CMOS detector** for much faster read-out and higher resolution, while maintaining low noise for up to 10 minute exposures. The Field-Of-View (FOV) of up to 125x100mm depends on the choice of detector and lens. Megapixel detectors with 14-bit ADC dynamic range make these deep cooled cameras suitable for **low-flux neutron imaging or high frame-rate x-ray imaging, with low noise**. Even binned 3x3 to increase intensity, the resolution is only limited by the scintillator

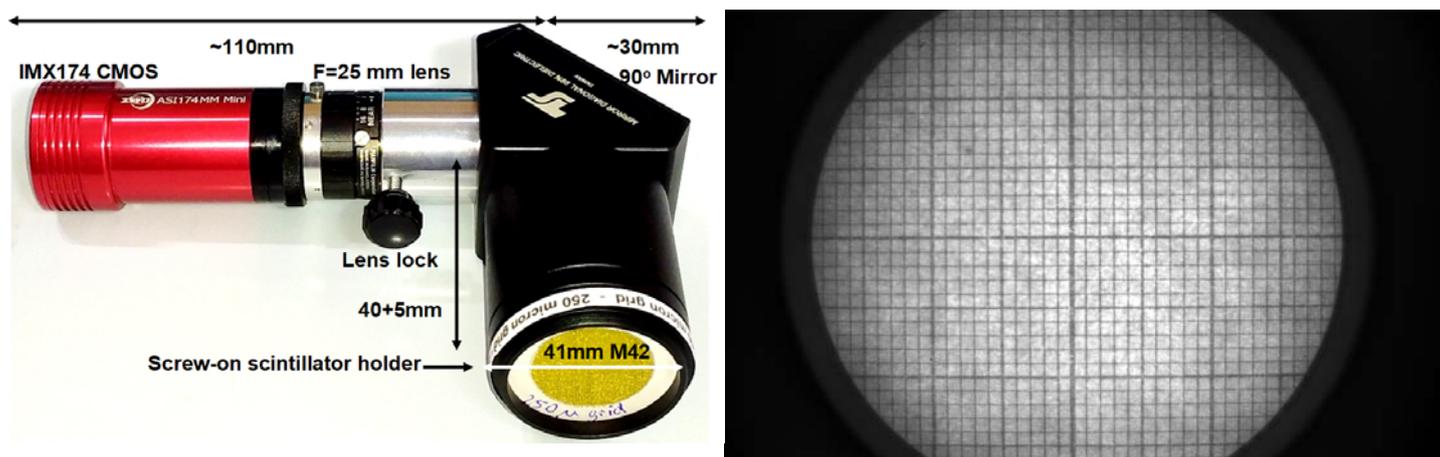


The camera is shown at left with a black-coated CAWO Agfa-Gevaert OG2 x-ray scintillator, but neutron scintillators behind thin aluminium windows can also be supplied.

### Choice of Detector

Detector	Square CMOS	4/3" CMOS	APS-C CMOS
Type	Pregius <a href="#">IMX533</a>	Pregius <a href="#">IMX294</a>	Pregius <a href="#">IMX571</a>
Lens Type & aperture	C- Fuji f/1.4	MFT 35mm f/0.95	MFT 35mm f/0.95
Typ Optical Path length	200-500mm	350-500mm	350-500mm
Resolution pixel	3000x3000	4144x2822	6248x4176
Image diag. mm	16 (1.1")	23 (4/3")	28 (APS-C)
Image area mm	11.3x11.3	19.1x13	23.5x15.7
Pixel size $\mu\text{m}$	3.76x3.76	4.6 x 4.6	3.76x3.76
Quantum effc	~80%	~90%	~90%
Fullwell e-	~50,000	~66,000	~50,000
Read noise e-	3	1.2-7.3	1.0-3.3
Dark c. e-/pix/s	0.001@-20 °C	0.002@-20 °C	0.003@0 °C
Peltier Cooling	$\Delta$ -35 °C or uncooled	$\Delta$ -35 °C	$\Delta$ -35 °C
Read time (s)	20 fps	16 fps	3.5 fps
A/D Readout	14-bits	14-bits	16-bits
Binning h,v	software	x1 x2	x1 x2 x4
Mount	C-or F-mount	M43-mount	M43-mount
Trigger signals	Software	Software	Software
Interface	USB2/USB3	USB 3.0	USB 3.0
Relative cost Detect+Lens	1.5-2	3	5

## High resolution over 40mm with CMOS-iCam and GdOx or CsI scintillators



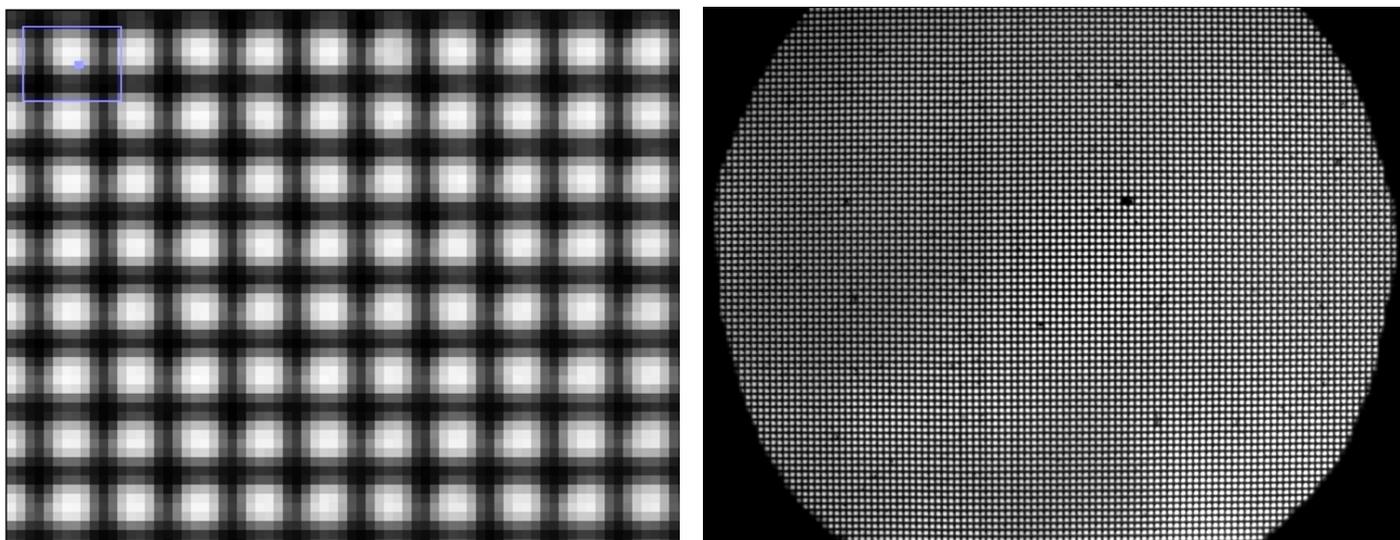
The ASI174mini iCam is a good choice when high resolution and fast acquisition is needed.

**To focus:** (closest focus is 40+5mm from mirror unit, already approx. correct)

- Use a paper grid at 40+5mm and unlock lens lock and lens focus screws
- Rotate camera+lens for best lens focus, then re-lock lens and lens focus screws
- Replace the grid by the scintillator, with its blue-FOP surface in the exact same 40+5mm plane
- You may need to slightly adjust the lens focus to optimise resolution in the x-ray beam
- Also try with the CAWO OG2 scintillator, with the white side facing the camera at 40+5 mm
- The scintillator is covered by a Carbon fibre or thin aluminium foil plate
- The cover plate and scintillator can be gently pushed from the scintillator holder
- The camera+lens can be pulled from the mirror unit to orient the camera around it's axis.

## Resolution, Frame-rates and Selected-Area Imaging

With a 25mm lens at closest focus for maximum magnification, the FOV is ~40mm diameter and the optical resolution ~25  $\mu\text{M}$ . The real resolution will depend on the scintillator and collimation.

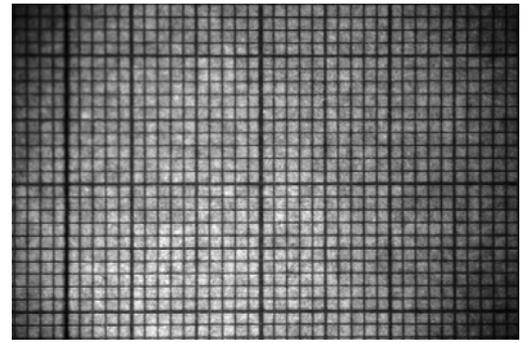


The left image shows a zoomed image of a 250  $\mu\text{M}$  wire grid, where the individual pixels are ~ 25  $\mu\text{M}$ . The right image shows the full grid on a selected area of the full frame. The frame rate for full 16-bit images is +7 fps. By selecting a small area frame rates of 200+ fps are possible over USB2.

The blue FOP (Fibre-Optic Plate) side of the 27x27mm #571135 [SCINTACOR columnar CsI](#) faces the detector, while the black protected CsI side, covered by a Carbon-fibre or Alu plate, faces the beam. High resolution GdOx scintillators [RC-TriTec](#), [SCINTACOR](#), [CAWO OG2](#) can also be used. Then the white scintillator side faces the camera.

**Familiarise yourself with camera operation on your desktop before placing it in the beam.**

# Full-frame IMX455 1:1 Macro camera with high resolution scintillators



**The full-frame IMX455 1:1 Macro camera (left)** offers optical resolution equal to the  $3.76 \mu\text{m}$  pixel size of the CMOS chip, with a FOV of  $36 \times 24 \text{ mm}$ . The FOV can be doubled using the scintillator extension, halving the resolution. The resolution and brightness is less than our Tandem Macro camera, with its FOV of only  $\sim 10 \text{ mm}$ .

**To focus (below):** Closest focus is  $\sim 40 \text{ mm}$  from the mirror unit

- Use the  $50 \mu\text{m}$  grid with ROI Capture area of  $1600 \times 1200$
- Pull focus ring up and rotate to near maximum extension
- Zoom SharpCap display to 800% to magnify the grid
- Push the focus ring down to lock the focus
- Replace the grid by the scintillator in the exact same plane
- Adjust the lens focus to optimise resolution in the beam
- Scintillators above are  $20 \mu\text{m}$  GadOx,  $450 \mu\text{m}$  LiF, OG2 x-ray, grid
- The real resolution depends on scintillator and beam collimation

## SharpCap 4 interface for focussing with the $50 \mu\text{m}$ wire grid

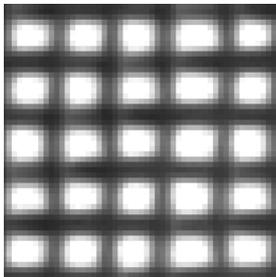
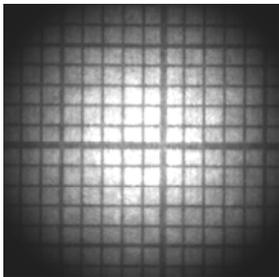
# Compact IMX533 1:1 Tandem Macro camera & high resolution scintillators



The Compact IMX533 1:1 Macro camera (left) is much brighter than our normal macro camera, with efficiency similar to that of fibre-optic coupling, [according to PCO](#). However the FOV is only ~11x11mm (below left), so we use the smaller [IMX533 square CMOS detector](#) (uncooled for short exposures). The face-to face 35mm f/0.95 lenses are focussed to infinity to give a 1:1 macro image of our 50 $\mu$  wire grid with 3.76  $\mu$ m pixels (below right).

## Focus - same as for the normal macro camera, except:

- One lens is locked on infinity, and the other used to focus
- Use the 50  $\mu$ m grid with ROI Capture area of 1600x1200
- The focus ring is stiffened with an elastic band (no lock)
- Zoom SharpCap display to 800% to magnify the grid
- Replace the grid by the scintillator in the same plane
- Adjust the lens focus to optimise resolution in the beam
- The real resolution depends on scintillator and collimation



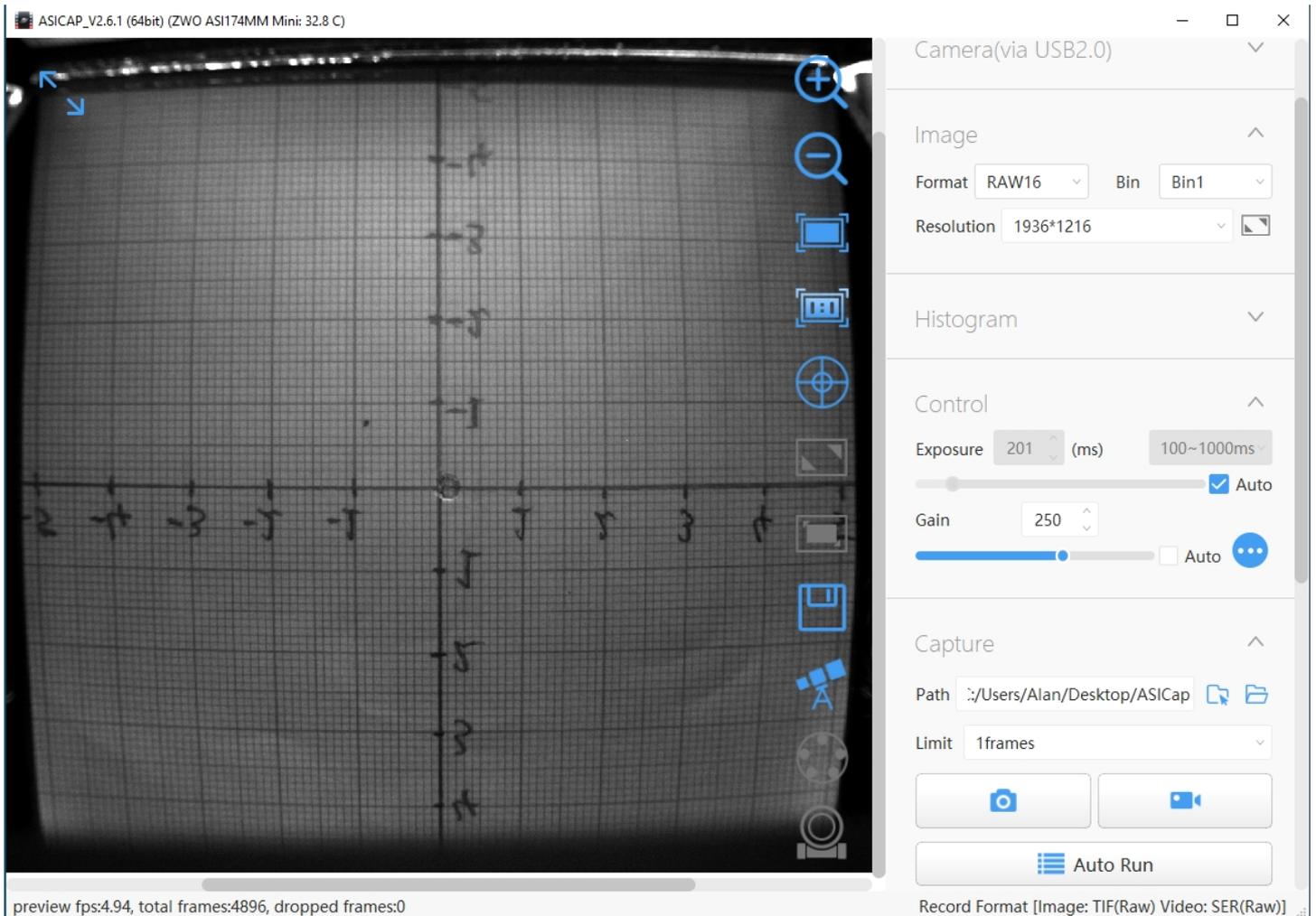
**Scintillators:** 20 $\mu$ m GadOx, 450 $\mu$ m LiF, OG2 x-ray, and grid. For neutrons and hard x-rays our [Gd<sub>2</sub>O<sub>2</sub>S:Tb/6LiF](#) PSI/RCTriTec scintillator on a 1.5mm thick aluminium plate can be used. Thinner scintillators such as [Scintacor hyperfine](#) are recommended for lower energy lab. x-rays.

## SharpCap 4 interface for focussing with the 50 $\mu$ m wire grid

## Native ZWO ASICap Viewer from ASIStudio

Use **ASICap** from [ASIStudio](#) to control the camera, but we recommend Windows [SharpCap4](#). **ASICap** becomes available after installing ASIStudio, and automatically recognises the camera. There is a help file available under the top right interrogation icon, but ignore all the astronomy help.

Prefer **RAW16** as the image format, with either 1x or 2x binning. This binning is performed by the camera driver after readout, and you can obtain much the same result by post-acquisition binning in ImageJ. Binning increases intensity at the expense of resolution. You can manually set the exposure and gain, or simply use automatically adjusted values. You can capture either a single image by clicking the camera icon, or a short video limited to n frames, by clicking the video icon. Otherwise the camera runs continuously without saving the frames. Hover the mouse over the icons on the right of the image display to understand their function - zoom in and out, zoom 100%, zoom to fill the available display area, draw crosshairs, display the full frame, move the ROI, and save the image. The last three icons are only used in astronomy.



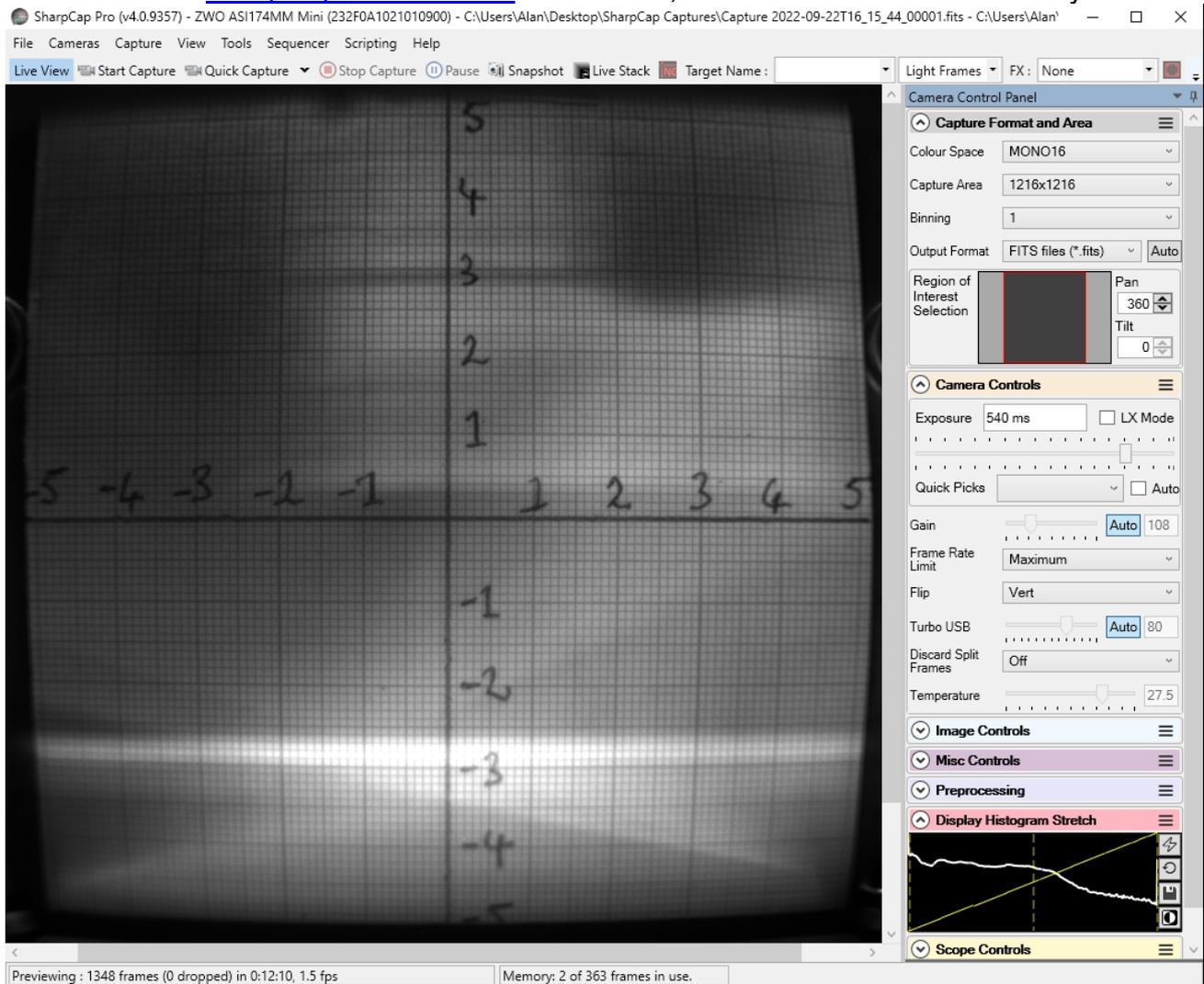
It is useful to choose a **Region-Of-Interest (ROI)** by setting a custom "Resolution" e.g.  $\sim 1000 \times 1000$  pixels centred on the  $100 \times 100$  mm window of the camera, and then zoom the ROI image to fill the screen. This corresponds to a real-space resolution of  $\sim 100 \mu\text{m}$ , the limit for standard scintillators.

**ASICap** may be sufficient for simple beam monitoring, and is available for both Windows, MacOS and Linux computers, but Windows **SharpCap4** offers more features. You can otherwise download the [ASCOM driver](#) and use many other astronomical imaging applications, including our simple PHD display application and our [ImageJ-for-ASCOM](#) interface which allows you to program complex acquisitions within ImageJ. Windows [MicroManager](#) and a [MicroManager Plugin](#) is also available, as well as a Windows [Direct Show driver](#).

**Experiment with different settings on your desktop before placing the camera in the beam.**

## Recommended SharpCap Viewer

Use [SharpCap4](https://www.sharpcap.co.uk/sharpcap/downloads) from the DVD or download it from <https://www.sharpcap.co.uk/sharpcap/downloads>. SharpCap was designed for low-light imaging by amateur astronomers, with more complete controls, including many you will not need for x-ray or neutron imaging. **Prefer the 64-bit version** for memory management. You must first install the ZWO driver. 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.



Zoom the image with Ctrl-mouse-scroll or the zoom selection at the top right. Set "**Capture Format**" to TIFF or FITS, Capture Area, and Mono16. In the "**Camera Controls**" set the Exposure (toggle LX mode for long exposures), set the Gain to zero (or increase it, at the expense of noise). Drag the vertical line in "**Display Histogram**" to stretch the intensity display to emphasise lower intensities. Zoom in to assist focussing. Focussing may be optimal when the Display Histogram maximises.

**Set a Custom Capture Area to the region of interest (ROI) and magnify it to fill the screen. e.g. set the Capture Area to ~1000x1000 centred on the 100x100mm camera window. Use 2x2 binning to increase intensity; the resolution is usually limited by the scintillator**

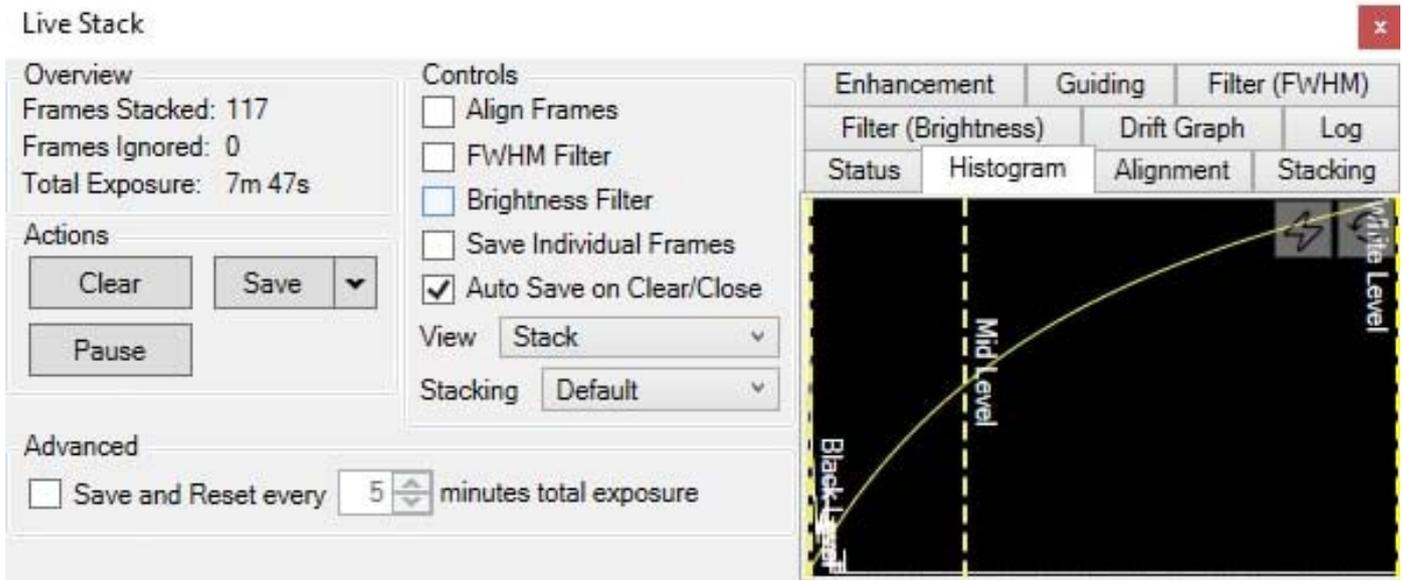
Click "**Snapshot**" to save a single image frame, or "**Livestack**" to sum several (see below).

In menu "**File/Settings**" check auto connect and restore, and 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.**

## Stacking short exposures in SharpCap

An interesting feature of SharpCap is real-time stacking of a series of short exposures. This allows you to judge when you have sufficient intensity. Click on the **"Live Stack"** icon above the image display to open this stacking window. You can drag this window so that it does not cover the image. Switch off **"Align Frames"** which refers to alignment based on stars. Most of the controls to the right are also for astronomers; only the live histogram is useful, but normally you might save the summed stack as a 32-bit image and filter noise from it with imageJ.



You can also use imageJ to stack a series of short exposures, which allows filtering of noise from the individual images before averaging. For very short exposures this may be better than averaging first and then filtering. Use the SharpCap menu **Capture/Start\_Capture** then enter the number of images to be saved. After capturing those images, use the ImageJ menu **File/Import/Image\_Sequence**, open the first image, and then OK to import all images in that directory into a displayed stack. Use **Image/Adjust/Brightness-Contrast** to examine the noise, and apply **Process/Noise/De-speckle** to all images. You may need to **De-speckle** twice. Finally sum or average the stack using **Image/Stacks/Z-Projection**.

For long stacked exposures you may see a diffuse background patch due to amplifier glow. Depending on the speed of your computer, frames may be dropped for frame rates >8 fps.

## FireCapture Imaging Software

[FireCapture](#) is another image capture application developed for amateur astronomy that you might also use for neutron and x-ray imaging.

## Hints on getting Optimal Performance from ZWO CMOS Cameras

- The centre of the image will not necessarily correspond to the centre of the window
- **Use Custom Capture area centred on your Region of Interest (ROI) to increase frame rate**
- **Use binning to improve signal/noise; the resolution is usually limited by the scintillator**
- The exposure time depends of course on the intensity of your beam
- You can always reduce image intensity by reducing the lens aperture
- Exposure time and frame rate can be controlled separately for short exposures
- **Use "Process/Noise/De-speckle" in [ImageJ](#) to remove noisy pixels from saved files**
- **Use automatic scaling in "Image/Adjust/Brightness-Contrast" in [ImageJ](#)**
- Use "Process/Remove Background" in [ImageJ](#) to remove diffuse background patches
- For serious imaging, subtract a "Dark Frame" to remove constant background
- Also use a "Flat frame" with no sample to calibrate the intensity across the FOV

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