marXperts

xraycam

User Manual

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X-ray Beam Camera for Alignment and Visualization

User Manual

Version 1.0

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Should you have questions concerning the system or its use, please contact us via phone or email.

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1. How to use this manual

Before you start to operate the xraycam please read the User Manual and the Technical Documentation included in the documentation package carefully.

2. Declarations

2.1 Europe CE

The instrument complies with the EMC Directives 2014/30/EU, the Low Voltage Directive 2014/35/EU as well as the RoHS directive 2011/65/EU.
Compliance was demonstrated by conformance to the following specifications listed in the Official Journal of the European Communities:

- EN61326-1: 2018 (Electrical Safety)
- EN61000-4-2:2001
- EN61000-4-3:2001
- EN61000-4-4:2001
- EN61000-4-5:2001
- EN61010-1
- EN63000: 2018 (RoHS)

2.2 Waste Electrical and Electronic Directive

End-users may return the instruments to Marxperts GmbH for disposal without being charged for disposal. This offer is valid only under the following conditions:

- the unit has been sold to a company or institute within the EU
- the unit is currently owned by a company or institute within the EU
- the unit is complete and not contaminated

The instrument does not contain batteries. The instrument does **not** contain neither lead (Pb) nor beryllium (Be). The instrument contains a tungsten (W) sheet (<2 g) as beam stop. If not returned to the manufacturer, it is the owner's responsibility to follow the local rules for disposing electronical equipment.

3. Safety Instructions

Please read these safety instructions before operating the camera.

3.1 Hardware Safety

- The xraycam must be operated with 5V. It obtains its power via the USB-C connector at the bottom of the instrument. Using an improper main voltage will destroy camera.
- Make sure that the camera is tighly connected to the holder arm and does not fall of the stand. Physical shock my damage the camera electronics or the optics inside.
- Avoid pressure or tension on the cables.
- The camera is not specified to withstand direct beam at a synchrotron. Such exposure will presumably damage the CMOS chip.
- Place the camera in its suitcase when it is not in use to prevent accidental damage.
- Opening the camera housing will void the warranty.
- Do not touch the front window of the camera. It contains a sensitive phosphor screen attached to a glass substrate, that may or may not resist physical stress.

3.2 Personal Safety

Since the purpose of the xraycam is to visualize the X-ray beam, ALL local precautions concerning the handling of X-ray sources must be strictly obeyed. The xraycam itself does not have any intrinsic safety features. Local directions concerning handling of X-rays differ from country to country. However, it is important to state out, that:

ONLY PROPERLY TRAINED OPERATORS SHOULD WORK WITH THE CAMERA

The camera housing is made of Aluminum which is not efficient for absorbing X-rays. For environmental reasons it does not contain lead. However, the X-ray beam entering through the front window will be blocked inside the camera by a series of measures, among others a tungsten beamstop of suitable size. The direct beam will not traverse the camera. Still, in order to minimize exposure to radiation, we strongly advise operators to:

STAY OUTSIDE THE RADIATION ENCLOSURE IF THE X-RAY BEAM IS ON

There usually is no need to break the radiation enclosure safety area and it must be emphasized, that operators should think twice, before they do. If they really have to work with open beam, we strongly advise operators to:

USE A SENSITIVE GEIGER COUNTER PRIOR TO APPROACHING THE CAMERA

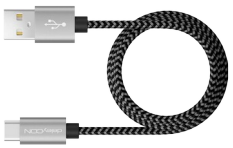
and verify that operation near the camera remains safe. Please note, that working with open beam is a severe safety risk that should be avoided by all means!

4. Specifications

Description	
Operating voltage	5 Volt via USB-C
Temperature range	-25 to +50 deg. C
CMOS chip	12 MP, approx. 4000 x 3000
Magnification factor	approx. 25 x
Field-of-view	approx. 30 x 18 mm

5. Hardware components

The device ships with the following components:

Description	
1. xraycam camera	
2. Magnetic base	
3. Spacer for flexible arm	
4. Flexible arm	
5. USB cable, 1,5 m, USB-C to USB-A • USB-A end connects to desktop PC or to OTG adapters • USB-C end connects to camera	

6. USB-OTG adapter
   - USB-C end connects to OTG compatible mobile device
   - Many modern smartphones will work without OTG adapter. You may just use a single USB-C cable

7. Foldable stand for mobile devices

8. Suitcase for camera and accessories

6. Usage

6.1 Physical setup

- Connect the magnetic base (2) with the spacer (3)
- Connect the spacer (3) with the flexible arm (4).
- Tighten the handle of the flexible arm (4) before attaching the camera, so the arm becomes stiff. If the flexible arm is loose, it will bend when the camera is attached and the camera may touch the ground!
- Lock the magnetic base to the surface by turning the knob counterclockwise to “On”. If the surface is not ferromagnetic, the magnetic base will not necessarily hold the camera in every position, in particular if the flexible arm is stretched out far to one side. The entire holder may tilt!
- Attach the camera (1) to the steel plate of the flexible arm (5). The camera features a strong Neodymium magnet on its back. It can be attached to any ferromagnetic steel surface.

- Attach the USB cable to the USB-C output at the bottom of the camera. Attach the USB-A connector to the USB-port of a PC or to a mobile device by using the OTG-adapter (USB-A to USB-C)
- Place the camera where you expect the X-ray beam to be, e.g. close to the exit window of the multilayer mirror housing.

6.2 Video connection

The xraycam works like a webcam. It is "UVC" compatible (USB video device class). This means, that it does not require drivers to be operated on operating systems (Windows, Linux, Mac, Android, iOS). Mobile devices must be OTG compatible, though. OTG stands for "on-the-go". The mobile device must be able to provide 5V via USB to external devices, and this was not necessarily the case in the past. Most modern mobile devices should be able to deal with it. Whatever operating system you are using, you will need a plain camera app or webcam app to see the video stream of the xraycam or other UVC devices. On Android, we are using "USB Camera Standard" (by Infinitegra, Inc.). There are tons of other choices.

7. Multi-layer mirror alignment

The following description is based on the procedure for a modern micro-focus X-ray generator equipped with a multi-layer mirror, e.g. the Anton Paar Primux 50 source with an AXO Astix optics. In current types of multilayer mirrors, two mirrors are typically arranged at an angle of 90 degrees to each other. The incoming primary beam will travel along the length of the mirror. Depending on the mirror adjustment angles, the primary beam will traverse the housing

- without being reflected
- be reflected by one mirror only
- be reflected by both mirrors

For X-ray experiments, only the double reflected beam component will be used as this component is the most monochromatic.

The situation is shown in Figure 1. The red and orange arrows are beam components that are reflected by both mirrors. The black arrow is the unreflected primary beam. For sake of clarity, the single reflected beam components are not shown. On a camera, the single reflected beam components might show up as thin lines in the upper and lower part of the image. Depending on the mirror alignment, the primary beam (here: the small dot in the

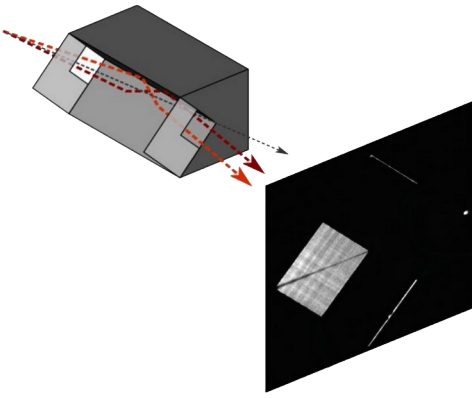


Figure 1: Reflection by 2 mirrors

right corner) might appear brighter than the double reflected beam (here: big square on left hand side).

Please note, that you will not see the four beam components if there already are some slits or collimation tubes mounted at the exit side of the mirror housing. Those hardware components may cut out the primary beam and single beam components and you may only see the double reflected beam component.

Please also note, that the mirror housing can accommodate the mirrors in the way depicted here, but the mirrors may also come rotated by 180 deg. In that case, the resulting image would look as above but flipped horizontally, i.e. with the double reflected beam on the right hand side.

WARNING: When working with open beam, you should be aware that exposure to X-rays can be a severe health hazard. You must follow ALL local safety regulations and you will have to be trained to safely operate X-ray devices before starting your work. Never put your hands close to the mirrors or into the beam path if the X-ray shutter is open. If the X-ray device is enclosed in an area protected by a safety interlock system, DO NOT BREAK the interlock! If for some reason you are forced to do that, understand all the risks involved!

The AXO mirrors come with 4 adjustment screws, 2 close to the X-ray source (#1,2) and 2 close to the exit window (#3,4). A detailed description on how to align the AXO mirrors from scratch is given elsewhere. Here, we assume that an rough alignment has already been done and that at least the primary beam component leaves the exit window of the mirror housing. In this case, it is usually sufficient to only turn the adjustment screws #3 and #4.

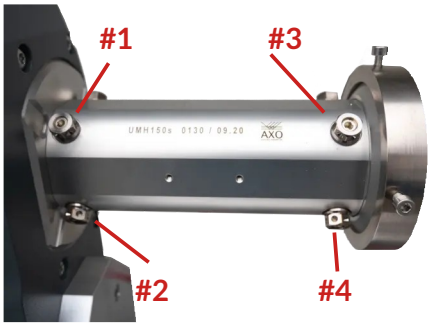


Figure 2: AXO mirror housing

- Operate the generator at low power, e.g. 40 kV and 100 microAmpere.
- Place the camera close to the exit window of the mirror housing.
- Open the X-ray shutter.
- If the X-ray beam passes the mirror housing unreflected, you will see the primary beam as a bright area on the monitor screen. Position the camera so that the primary beam is near the center of the image. If the beam is very weak, try to go to higher power settings.
- If you see nothing but the primary beam, turn both mirror adjust screws #3,4 counterclockwise to increase the combined grazing angle. If you start seeing the single reflected beam components, you may turn #3 and #4 in opposite directions in order to get a symmetric pattern. Try to adjust the mirrors such that the separation

between the beam components is as large as possible but without the intensity of the reflected beam decreasing in intensity.

- If you already see more than one beam component, turn screws #3,4 in either direction. The goal is to achieve a pattern similar as shown above with the double reflected beam to be as bright as possible and to have a nice square shape which is just a consequence of the squared entry and exit windows of the mirror housing.

If the four spots are not visible it may be necessary to move the camera left-right and up-down slightly in order to find the correct position.