Alignment of the camera (Item No.: P2550600)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
ILIAS	Physik	Hochschule	Moderne Physik	Röntgenphysik

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Difficult	1 Hour	2 Hours	2 Students

Additional Requirements:

- PC
- Sample for CT-Scan

Experiment Variations:

Keywords:

Detector Alignment, Rotation axis, tilt

Overview

Short description

Principle

Alignment of the detector and the rotation stage is very important to get optimal quality images of a CT scan. In this experiment, the different possible misalignments and their correction are studied and de-scribed.

Fig. 1: Experimental set-up

Student's Sheet

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Equipment

Position No.	Material	Order No.	Quantity
1	XRE 4.0 X-ray expert set, with tungsten tube	09110-88	1
2	XRCT 4.0 X-ray Computed Tomography upgrade set	09180-88	1

Tasks

1. Optimise the COR and correction.
2. Optimise the tilt and correction.

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Set-up and Procedure

Set-up

Attach the XRIS to its stage.

Place the Digital X-ray detector XRIS on the rail at position $30\,\mathrm{cm}$. The back side of the XRIS stage cor-responds to its position on the rail. This position is called the 'source to detector distance' SDD (mm). Connect the usb cable between the detector and the computer

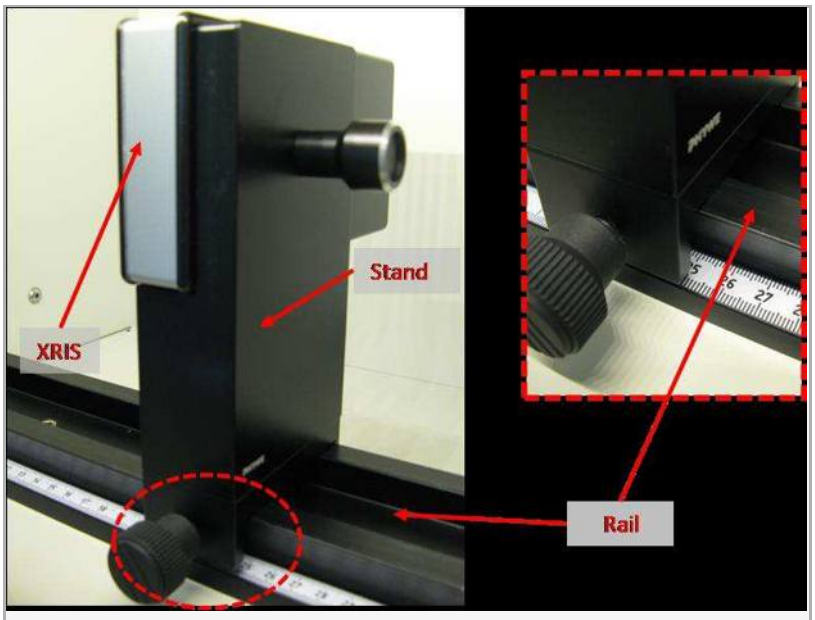

Fig. 2: Set-up of the XRIS

Place the rotation stage XRstage on the rail at position $25\,\mathrm{cm}$. The back side of the XRstage corre-sponds to its position on the rail. This position is called the 'source to object distance' SOD (mm).

Connect the XRstage cable with the 'Motor' connection block in the experiment chamber. Attach the sample table to the XRstage with the fastening screw.

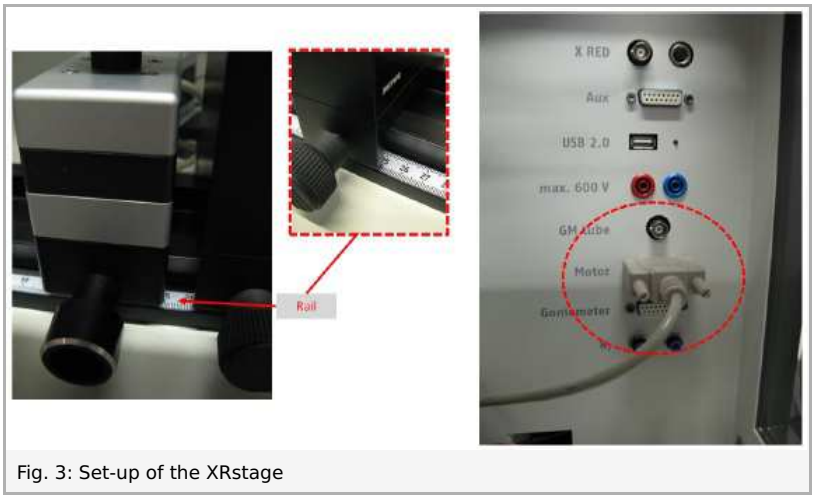

Fig. 3: Set-up of the XRstage

Connect the X-ray unit via USB cable to the USB port of your computer (the correct port of the X-ray unit is marked in Fig. 3).

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Fig. 4: Connection of the computer

Procedure

- Start the “measureCT” program. A virtual X-ray unit , rotation stage and Detector will be displayed on the screen. The green indication LED on the left of each components indicates that its presence has been detected (Fig. 5).
- You can change the High Voltage and current of the X-ray tube in the corresponding input windows or manually on the unit. (Fig. 5).
- When clicking on the unit pictogram additional information concerning the unit can be re-trieved (Fig. 5).
- The status pictogram indicate the status of the unit and can also be used to control the unit such as switching on and off the light or the X-rays (Fig. 5).
- The position of the XRIS and XRstage can be adjusted to its real position either by moving the XRIS pictogram or by filling in the correct value in the input window (Fig. 5).
- The settings of the XRIS can be adjusted us-ing the input windows. The exposure time controls the time between two frames are re-trieved from the detector, the number of frames defines how many frames are aver-aged and with the binning mode the charge of neighbouring pixels is averaged to reduce the total amount of pixels in one frame.

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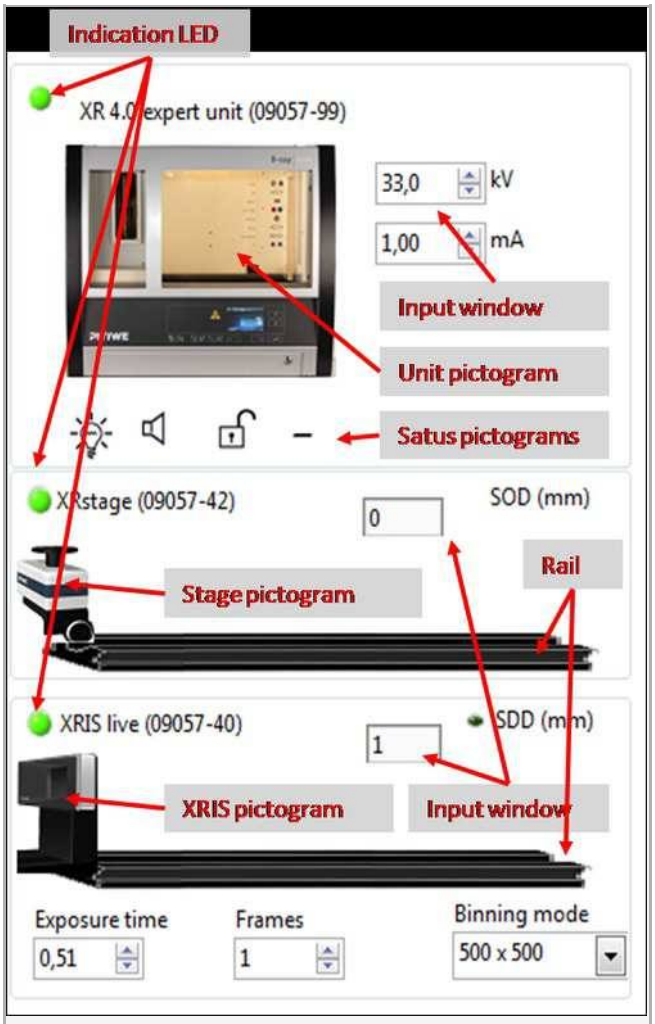

Fig. 5: Part of the user interface of the software

Experiment execution

1. Optimise the COR and correction

- Adjust the XRIS settings and X-ray unit settings according to fig 6 or load the configuration from the predefined CTO file 'Experiment 6' (see Fig. 6).

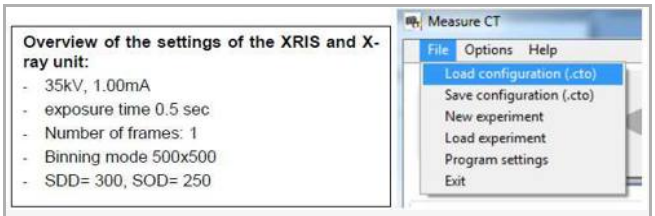

Fig. 6: The settings for this experiment (left panel) and the method load and adjust the settings (right panel)

- Start a new experiment, give it a unique name and fill in your details (Fig. 7). Alternatively it is also possible to load this experiment with pre-recorded images and open this manual. The correct configuration will be loaded automatically as well but the functionalities of the software will be limited to avoid overwriting the existing data.

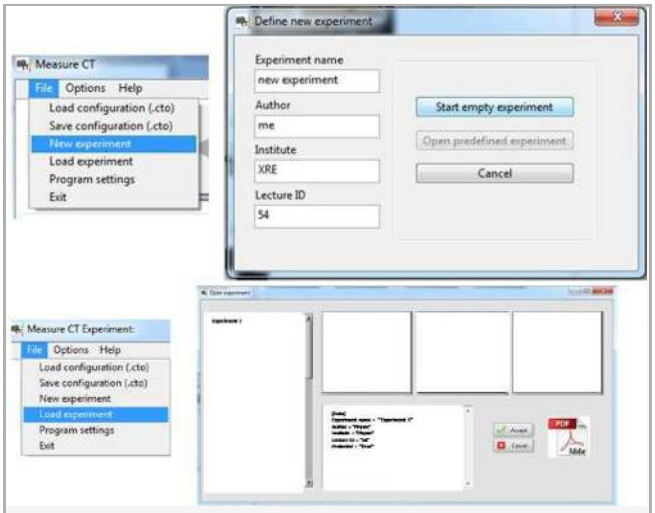

Fig. 7: How to create a new or open an existing experiment

- Switch on the X-rays (Fig. 8.1) and activate the 'Live view' (Fig. 8.2). When the Live view is activated, every new image that is retrieved from the X-ray detector is displayed. The Detector exposure load bar (Fig. 8.3) indicates the average degree of fill for each pixel. **It is very important to remain be-low the maximal fill degree of the detector**. Otherwise the detector will be saturated and won't work properly. If the saturation level is reached, the 'detector exposure' load bar will turn red. (see experiment 1 for more details).
- Calibrate the detector by clicking on "Calibrate'(Fig. 8.4). When the calibration is successfully per-formed, the indication LED (fig. 8.5) will turn green. The Load bar (Fig. 8.3) will disappear and the Contrast/intensity cursor (Fig. 8.6) will become available. (see experiment 1 for more information).
- Place object on the sample stage and close the door.
- Adjust SOD (Fig. 8.7) and SDD (Fig. 8.8) in the software according to the actual position.

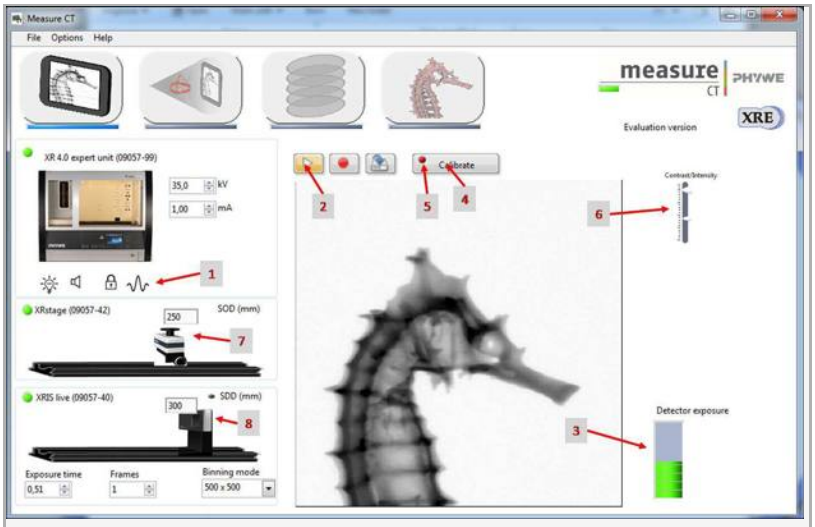

Fig. 8: Settings to set before start of a CT-scan, part 1

- Go from the "Live view page" to the "CT scanning page". The indication pictogram will turn blue when the page is activated.

Fig. 9: CT scanning page

- Start a CT scan (Fig. 10.1). During the CT scan the progress (Fig. 10.2) as well as the remaining time (Fig. 10.3) is displayed. The current image (Fig. 10.4) being recorded is shown and the temporary result (Fig. 10.5) is calculated during

the scan. It is also possible to track the position of the rotation (Fig. 10.6). When the scan is finished it is possible to replay the acquisition as a simulation (Fig. 10.7).

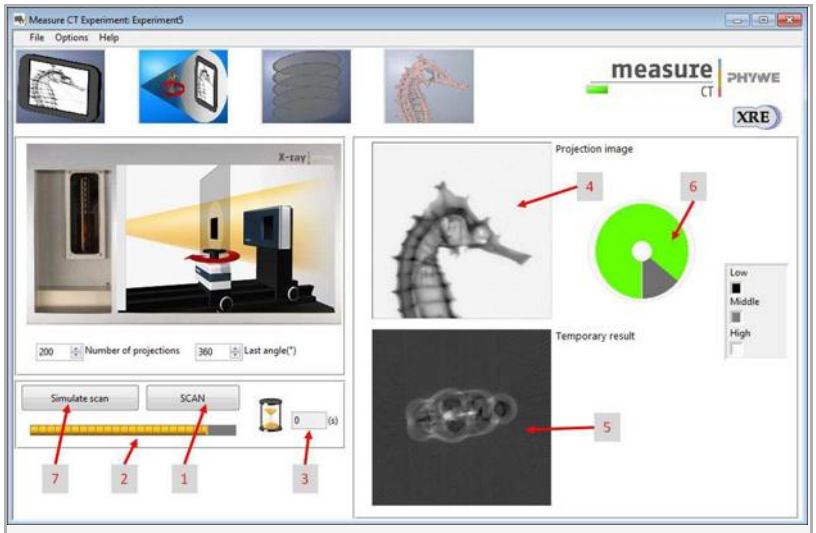

Fig. 10: Start a CT-scan

- When the CT scan is finished it is possible to proceed to the reconstruction. Go from the "CT scanning page" to the "Data reconstruction page". The indication pictogram will turn blue when the page is activated.

Fig. 11: Data reconstruction page

- Change the COR value until the image looks as sharp as possible. The optimal value for the cen-tre of rotation is 250. The detector itself is 1000x1000 pixels, meaning that the central pixel col-umn is 500. When the detector is used in 500x500 binning mode, the central pixel column is 250,....

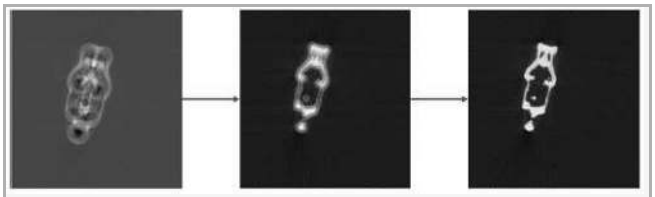

Fig. 12: Optimisation of centre of rotation

- If the COR is between 240 and 260, it is very close to optimal. This value can also be saved in the default settings of the software so that it automatically uses this value for the next reconstruc-tions (**Note:** the software will have to be restarted first).
- Unscrew the rotation stage and position it further away from the door. Rotate the object using the manual rotation positioning on the unit between 0°-180° and between 90°-27°. If the object re-mains in the field of view of the detector, the rotation is well aligned.
- Perform several times a scan to check for the influence of this parameter.

2. Optimise the tilt and correction

- Loosen the screw at the back of the detector and tilt the detector as much as possible, than re-tighten the screw.

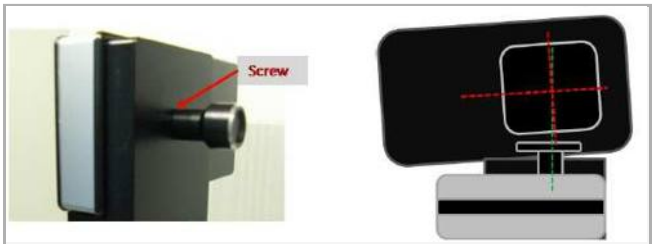

Fig. 13: Detector tilt

- Recalibrate the detector.
- Place object in the XRstage.
- Perform a CT scan with the same parameters.
- After the scan, go to the reconstruction tab.
- The effect of the reconstruction parameters can be tested with the test button (Fig. 14.1). The re-sult is displayed (Fig. 14.2) for a certain slice (Fig. 14.3) which corresponds to a certain row of the detector (Fig. 14.4). The SOD and SDD (Fig. 14.5) parameters should not be altered if they corre-spond to the physical position of the XRstage and XRIS.

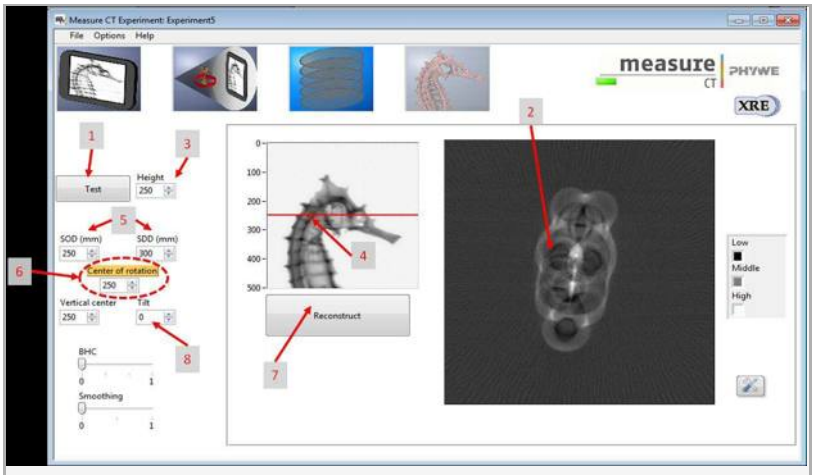

Fig. 14: Data reconstruction page and buttons

- Start with optimising the COR for the central detector row (height= 250). When this value is optimal, change the height to 50 and test. Since the detector is misaligned the image should be blurry again. Instead of adjusting the COR value, change the tilt value (Fig. 14.8) until the image is sharp.
- During tilting of the detector, it is possible that the vertical centre has slightly changed. This can be checked by testing the slice at row 450. If the result is still as sharp as for row 50, the vertical centre is still good. In case it is not the vertical centre will have to be altered until the result is better. Tip: start with big changes in altering the vertical centre and then iteratively smaller down the step until the result looks good.
- If the vertical centre was changed: Go back to row 50. Very probably the result won't look good anymore, start again with changing the tilt, go to row 450 and adjust the vertical centre. Repeat this operation until both row 50 and 450 are sharp.
- Now you managed to define the reconstruction parameters with a misaligned detector. Change the tilt again to a better alignment and perform a CT-scan. Check whether there is tilt. In case there still is, try to improve it as much as possible.

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Theory

Alignment

One of the crucial parameters for a CT scan is the correct alignment of the setup. During the reconstruction, the software presumes that the rotation of the sample is according to the set parameters, if this is not the case, the reconstruction will be incorrect and the data sub-optimal.

In an ideal situation, the source, detector and rotation stage are all perfectly aligned on the optical axis. The optical axis is defined as an axis perpendicular to the detector plane, through the spot of the X-ray source.

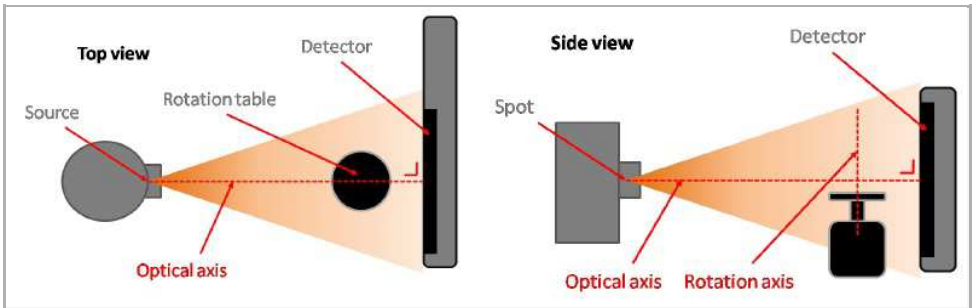

Fig. 15: Set-up

The detector is well positioned if the optical axis intersects with it in the central pixel. The rotation stage is well positioned if its rotation axis (the axis around which the sample rotates) intersects in a perpendicular way with the optical axis.

There are many possible misalignments, the most important ones can be corrected either manually or in the measureCT software. These misalignment are described here:

- Centre of rotation (COR):

If the rotation axis is not coinciding with the optical axis, the COR will not correspond with the central pixel of the detector (see Fig. 16).

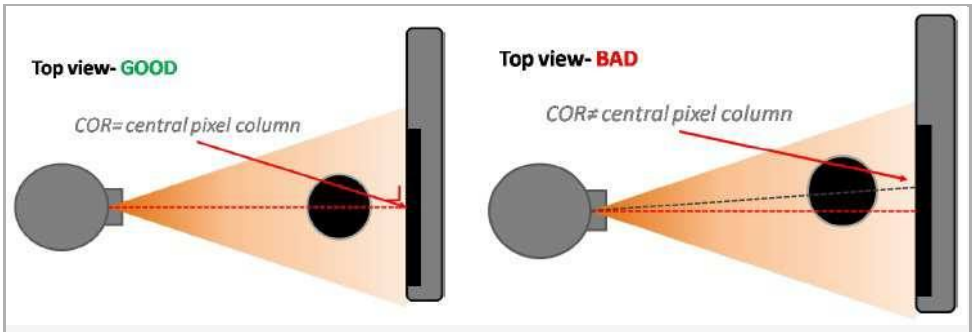

Fig. 16: Centre of rotation

This can have two effects. The first is that the images look blurry. This can best be resolved by adjusting the COR value in the reconstruction tab of measureCT (see Fig. 14).

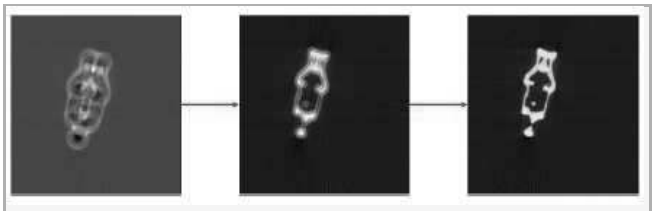

Fig. 17: Centre of rotation correction

The second effect is that, if the object is relatively large, it will not fit on the detector anymore during the rotation in a scan. This will cause some image artefacts due to missing information (see Fig. 17). This can best be resolved by manually moving the XRstage. (Unscrew the fastening screw and position it so that the objects fits on the detector at all times of the rotation.)

- Tilt and vertical centre:

The main detector misalignment occurs when it is not parallel with the rotation axis (Fig. 18).

The software presumes that the COR is identical for the all the pixels rows but if the detector is tilted, the COR will be vary from top to bottom pixel rows. By adjusting the tilt parameter in the reconstruction, this can be corrected. Note: the vertical centre is the height around which the images are tilted for correction, in some cases this needs to be adjusted to get optimal results.

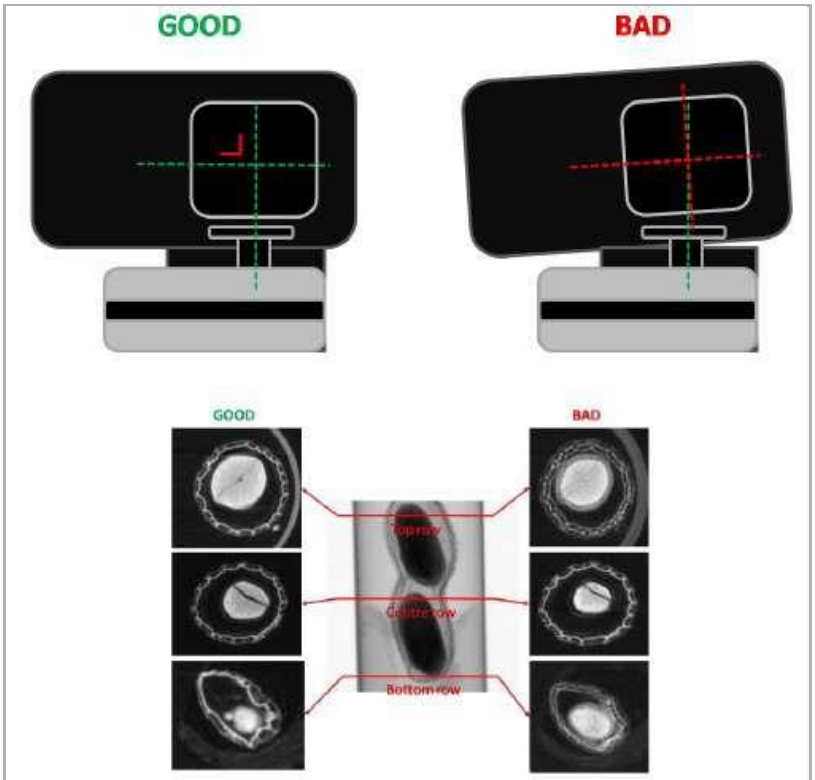

Fig. 18: Tilt and vertical centre

- Source detector distance (SDD):

Less crucial but still important is the correct SDD. in case this value is incorrect, the software will not take the correct cone-angle into account and the reconstruction will be suboptimal.

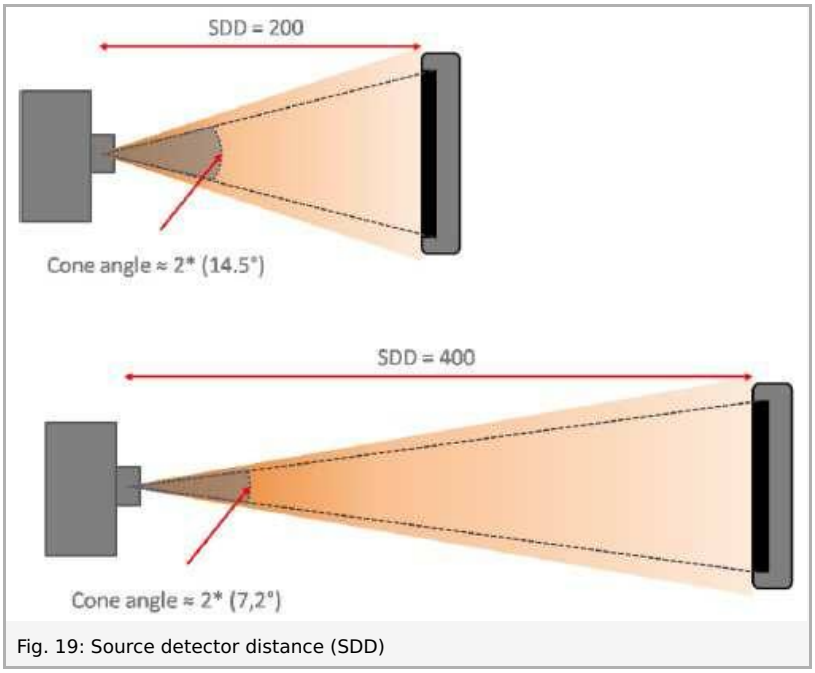

Fig. 19: Source detector distance (SDD)