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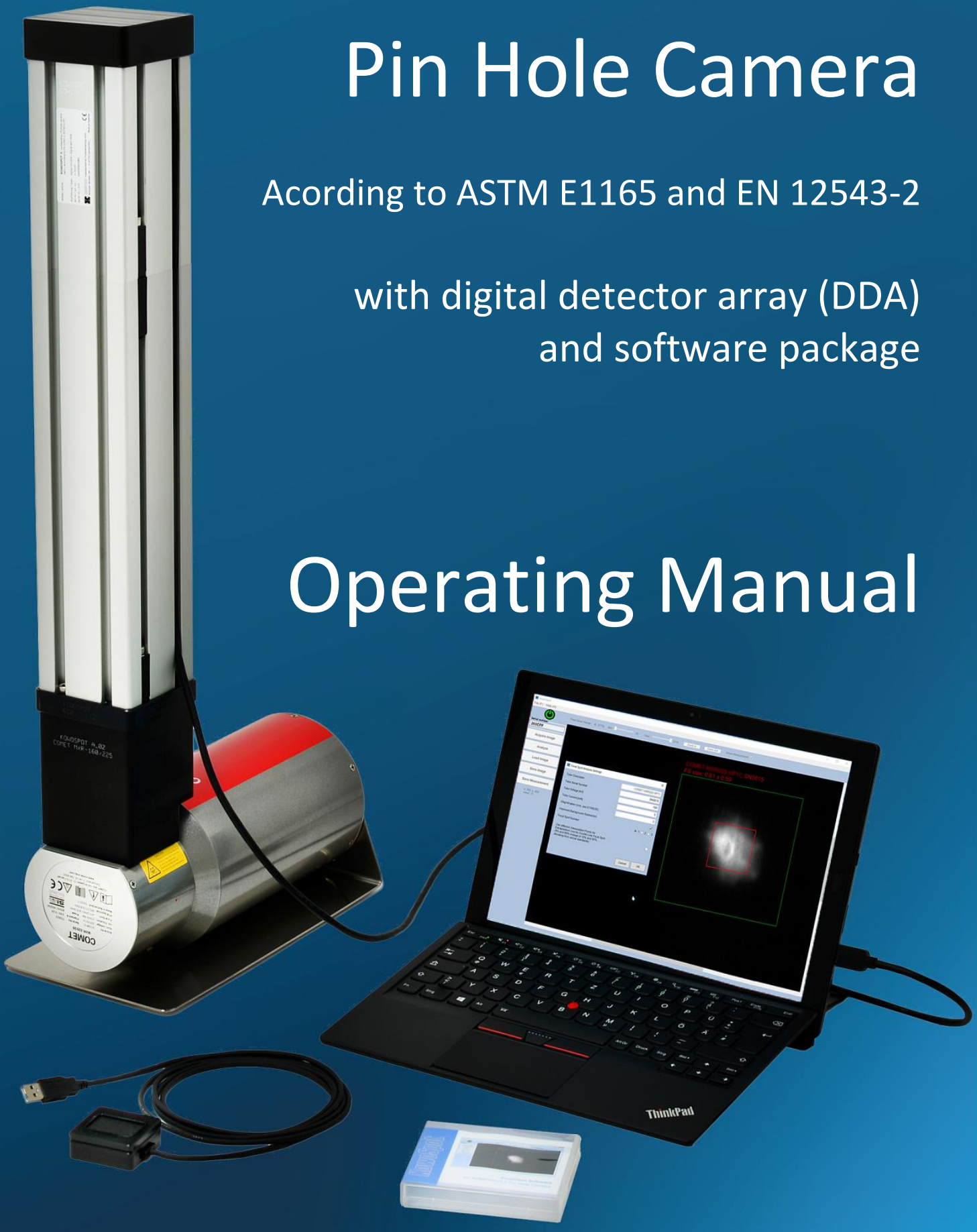
KOWOSPOT X

Pin Hole Camera

Acording to ASTM E1165 and EN 12543-2

with digital detector array (DDA)
and software package

Operating Manual



Content:

1 General

This user manual refers to the Kowotest Pinhole Focal Spot Camera
KOWOSPOT X
and the Software
KowoSpot.

1.1 Intended use

The KOWOSPOT X is intended for the measurement of focal spot sizes in reference to ASTM E1165-20 and EN12543-2. It uses a pinhole to project the focal spot image on a digital detector. It is a standalone tool; no other hardware and software beside the delivery and a PC running WIN 10® operation system are required.

Pinholes are available with nominal diameters of 10µm, 30µm, and 100µm.

Required magnifications can be adjusted with different numbers of modules in front and behind the pinhole module. The recommended magnifications are given in Table 2 of ASTM E1165-20.

The digital version consists of the parts of the analogue version of the KOWOSPOT, together with a Digital Detector Array (DDA) and an easy to use software package.

The digital version of the KOWOSPOT camera allows a fast stand-alone measurement of focal spots with sizes from ~50µm up to 5mm (focal spot classes FS0 to FS20).

1.2 Improper use

Any other use apart from that intended is prohibited.

1.3 Symbols

The following symbols are used for identification in the user manual and within the system.

WARNING

Warning of dangerous X−radiation

If improperly used, X−radiation may constitute a risk to the life and limb of the user or third parties.

Familiarity with the fundamental safety reminders and safety regulations is essential for the safe handling and trouble−free operation of the X−ray system.

Safety reminders and safety regulations must be adhered to at all times.

Note: this symbol is used when special notes are to be observed.

Tip: this symbol will give you application tips and especially useful information. They will help you to use all functions on your unit/system optimally.

2 KOWOSPOT Camera (Hardware)

This part of the user manual refers to the Hardware of the Kowotest Pinhole Focal Spot Camera.

2.1 Modules of the camera

The KOWOSPOT X hardware consists of the following elements

A: Tube adapter
(here: Adapter for a COMET tube)

B: Pinhole element

C: Profile elements
(here: 3 x V1
with n=15cm each
for n/m = 4:1)

D: Detector element
with digital detector

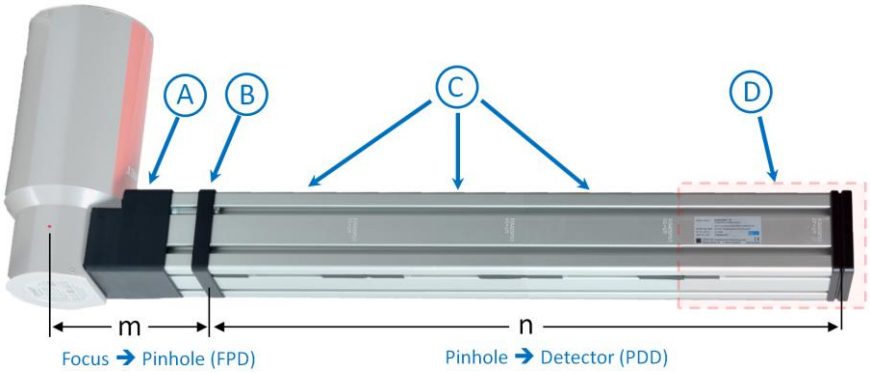


Fig. 2.1: KOWOSPOT X Focal Spot Camera Hardware for a "magnification" n/m of 4:1

E: Digital element D fixture

F: Digital Detector Array (DDA),
called sensor in the
KOWOSPOT SW,
with housing

G: Cable with USB Plug

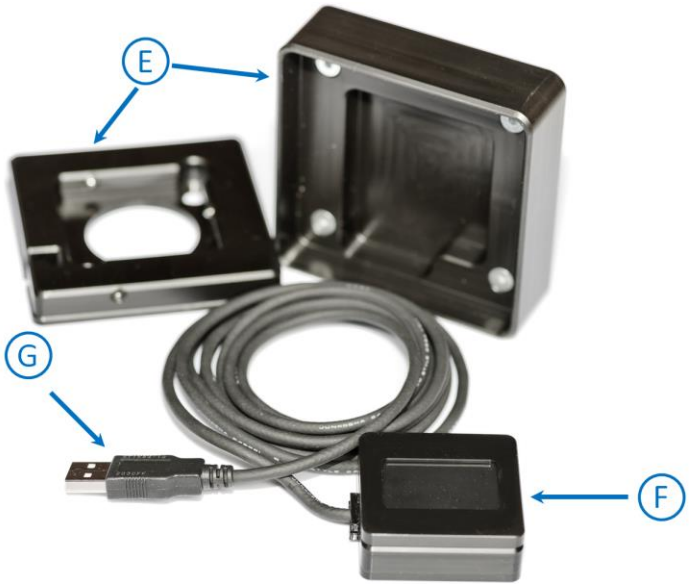


Fig. 2.2: Digital Detector Element (right) and active USB extension cable (left)

The modularity of the systems allows you to configure your camera for the focal spot size you want to measure.

The following table shows the configuration with the different number of modules **C** with V1 (15cm length) or V2 (30cm length) each (two V1 are standard),
one of the three different Pinhole Elements (**B**10 [10µm], **B**30 [30µm], or **B**100 [100µm]),
and the detector element **D** which also has a length of 15 cm to the active detector surface.

Focal Spot		max.	min.	min.	min.		Tube	Pinhole	Profile Elements "C"			Detector	USB
Class	Size φ	Pinhole	FPD (**m**)	PDD (**n**)	**n / m**		Adapter	Element	#V1 *	# V1 opt.	# V2 opt.	Element	Ext. Cable
	[µm]	Diam. **P**	[cm]	[cm]			[AD]	[B µm]	(15cm)	(15cm)	(30cm)	(15cm)	(plus 5m)
FS 20	50	10	15	135	9:1		opt.	B10	2		3	D	opt.
FS 19	63	10	15	120	8:1		opt.	B10	2	1	2	D	opt.
FS 18	80	10	15	120	8:1		opt.	B10	2	1	2	D	opt.
FS 17	100	10	15	105	7:1		opt.	B10	2		2	D	opt.
FS 16	127	10	15	90	6:1		opt.	B10	2	1	1	D	opt.
FS 15	160	10	15	90	6:1		opt.	B10	2	1	1	D	opt.
FS 14	200	10	15	75	5:1		opt.	B10	2		1	D	opt.
FS 13	250	10	15	60	4:1		opt.	B10	2	1		D	opt.
FS 12	320	10	15	45	3:1		opt.	B10	2			D	opt.
FS 11	400	10	15	45	3:1		opt.	B10	2			D	opt.
FS 10	500	30	15	45	3:1		opt.	B30	2			D	opt.
FS 9	630	30	15	45	3:1		opt.	B30	2			D	opt.
FS 8	800	30	15	45	3:1		opt.	B30	2			D	opt.
FS 7	1000	30	15	45	3:1		opt.	B30	2			D	opt.
FS 6	1270	30	15	45	3:1		opt.	B30	2			D	opt.
FS 5	1600	100	15	45	3:1		opt.	B100	2			D	opt.
FS 4	2000	100	15	45	3:1		opt.	B100	2			D	opt.
FS 3	2500	100	15	45	3:1		opt.	B100	2			D	opt.
FS 2	3200	100	30	30	1:1		opt.	B100	2			D	opt.
FS 1	4000	100	30	30	1:1		opt.	B100	2			D	opt.
FS 0	5000	100	30	30	1:1		opt.	B100	2			D	opt.

* 2 C-Elements V1 are the standard; opt. means “optinal”

Table 2.1: Configurations of KOWOSPOT X for different Focal Spot Classes (ASTM E1165-20)

C: **C**-element with 15cm length

D: **D**-element with 15cm length and DDA

G: Collimator

H: Internal shielding

K: DDA

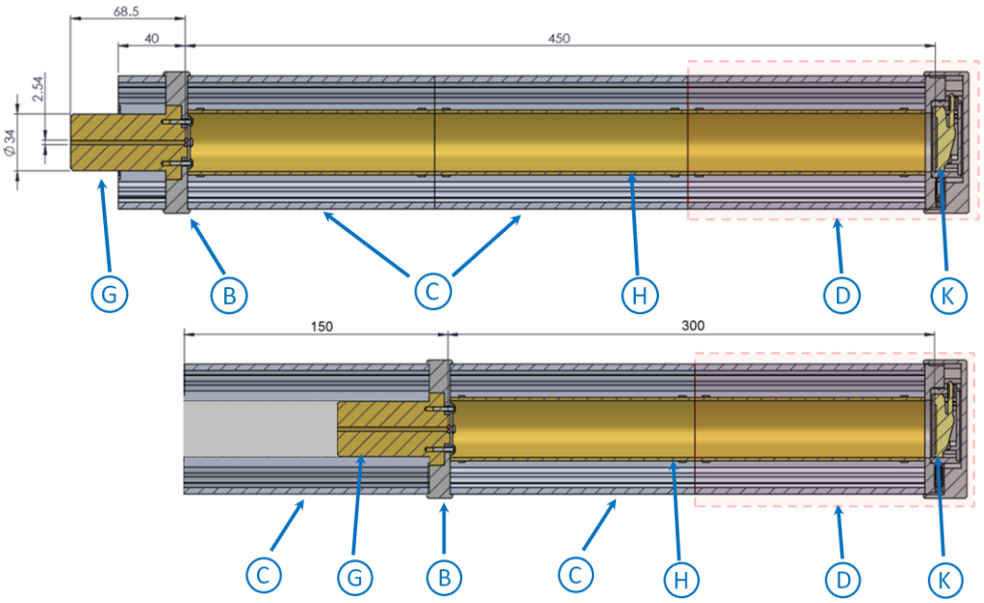


Fig. 2.3: Example of a KOWOSPOT X for a “magnification” n/m of 3:1 without tube adapter A and for a “magnification” n/m of 1:1 without tube adapter A on the left side

If different focal spot sizes below 320µm are to be measured, it is recommended to buy a set of C elements to be able to get the required magnifications n/m for the different focal spot sizes (see Table 2.1 and Chapter 6.1).

The smallest pinhole element with a 10µm pinhole could also be used for focal spots larger than 400µm. Only the signal is reduced. According to our experience the 10µm pinhole is fine up to 2mm.

2.2 Alignment of the camera

The KOWOSPOT X has a modular hardware and is mounted from different modules to meet the requirements of different focal spot classes. But the modules are constructed in a way that a correct alignment is given be default. It should be as shown in Fig. 2.2.

By definition in the standards like ASTM E1165 Fig.4, the direction of evaluation from anode to cathode defines the length of the focal spot. Mainly this is the direction of the high voltage cable or cables (bipolar tubes).

The direction perpendicular to the high voltage cable is defined as focal spot width.

The mechanics of the KOWOSPOT X shows a red dot on the pinhole element (B). The mechanic of the KOWOSPOT X shall be mounted that the cable of the detector K in the element D is at the same side and direction as the red dot of the pinhole.

Then the directions of the focal spot in the detector image are as follows:

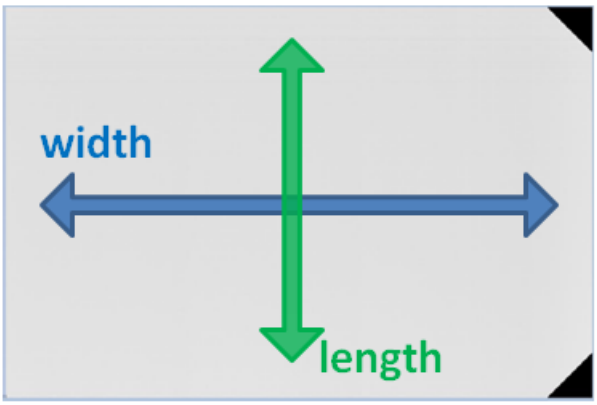


Fig. 2.2: KOWOSPOT X alignment to get the correct direction of length and width

There are different tube head adapters (A) available from Kowotest. Some of them fit only in one position to the tube. But there are also adapter available which have two or four options for fixture. The get the correct definition of focal spot length and focal spot width the user should ensure that the red dot of the pinhole element (B) and at the same time the cable output of the detector element (D) are visible when looking on the tube from the side.

3 KOWOSPOT Camera (Software KowoSpot)

This part of the user manual refers to the KowoSpot Software. The installation of the software is described in Chapter 5.

Before starting a measurement, the detector has to be plugged in; an USB 3.0 interface is recommended, but an USB 2.0 will also run. If required, the cable can be extended by the USB active extension cable by additional 5m.

3.1 KowoSpot start page

When the KowoSpot software is started, if comes up in full screen mode. The user interface consists of the following buttons and functions:

1. Menu bar
2. Start button to activate the detector
3. Buttons for operations in control menu
4. Slider for lower and upper thresholds of display window
5. Adjust zoom factor
6. Scroll bars to for position the focal spot in the displayed image
7. Standard Windows® icons for full screen mode and to exit the program.

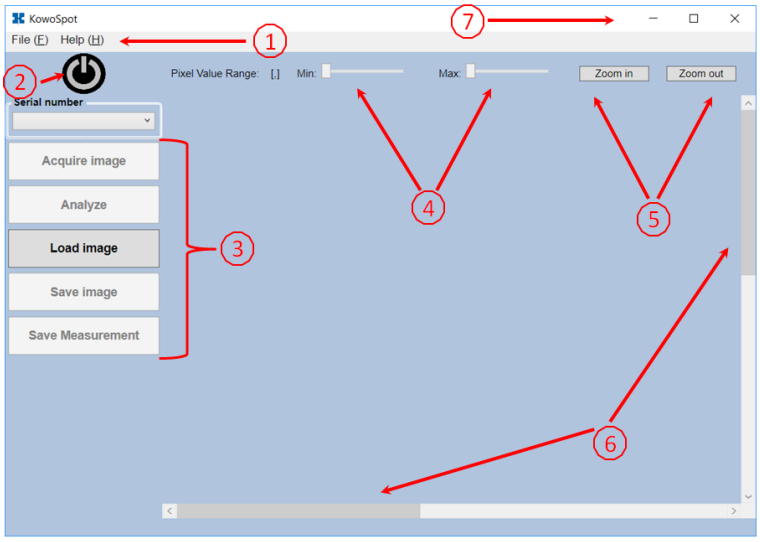


Fig. 3.1: Screenshot after starting the software before initialization of detector (2)

2. Green color: Detector active and detector no. .
4. Left side: Min./max. Pixel values in complete image
   Slider for lower and upper thresholds of display window and selected values
8. Pixel value at mouse position X/Y
9. Shows results of measurement as overlay on focal spot image

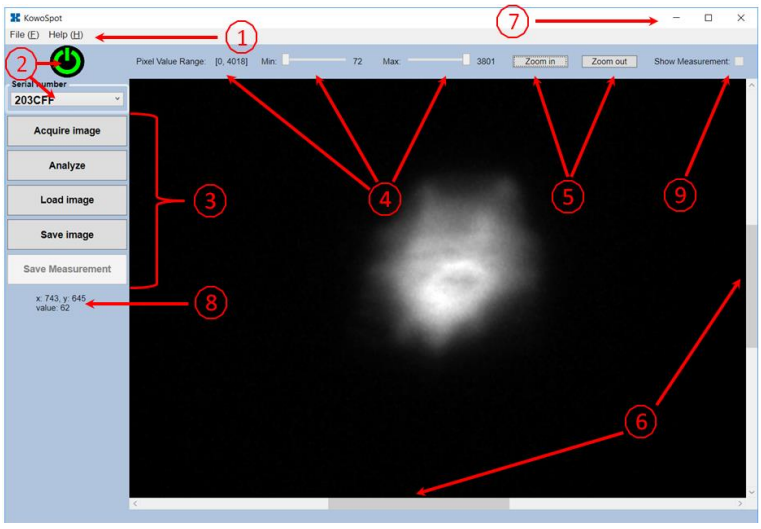


Fig. 3.2: Screenshot with active detector and acquired focal spot image

The red numbers in Fig. 3.1 and Fig. 3.2 are used within this chapter for explanation.

3.2 KowoSpot menus (1)

The menus of the KowoSpot software are quite simple as the software is controlled by the buttons (3) on the left side.

Menu entries:

File (F) may be used to exit the software

Help (H) shows the about box and a link to the documentation in PDF format.

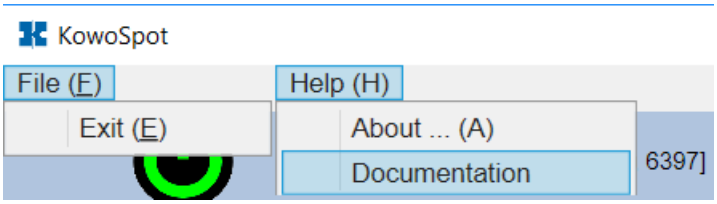


Fig. 3.3: The menus **File** and **Help**

3.3 Starting the detector (2)

When the detector is plugged in, press the round button (2) and start the connection to the detector.

If you get the following error message, the software cannot detect a proper sensor (DDA). Ensure the USB cable is plugged in and – in case of using the extension – this cable is also plugged in.

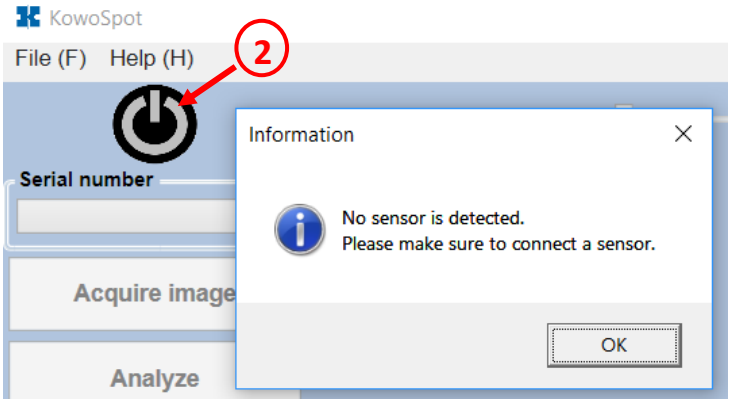


Fig. 3.3: Error-Message when no DDA can be detected by the software

When the detector is detected by the software the button (2) will change its color to green and the serial number of the detector will be displayed below the button.

At once the software will acquire two images with 1s internal integration time. This is done to display the sensor offset signal on the monitor for the operator to check the image.

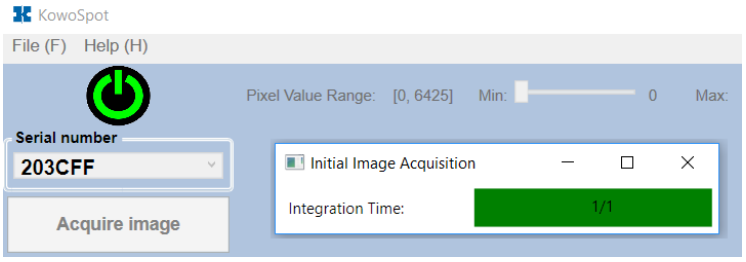


Fig. 3.4: Two initial images are acquire by the software at startup

The pixel value range of the offset image is in the range of about 5200 to 6600. All focal spot images will be offset corrected. To check the quality of the image the sliders (4) can be used and the pixel value at the mouse position is shown in (8).

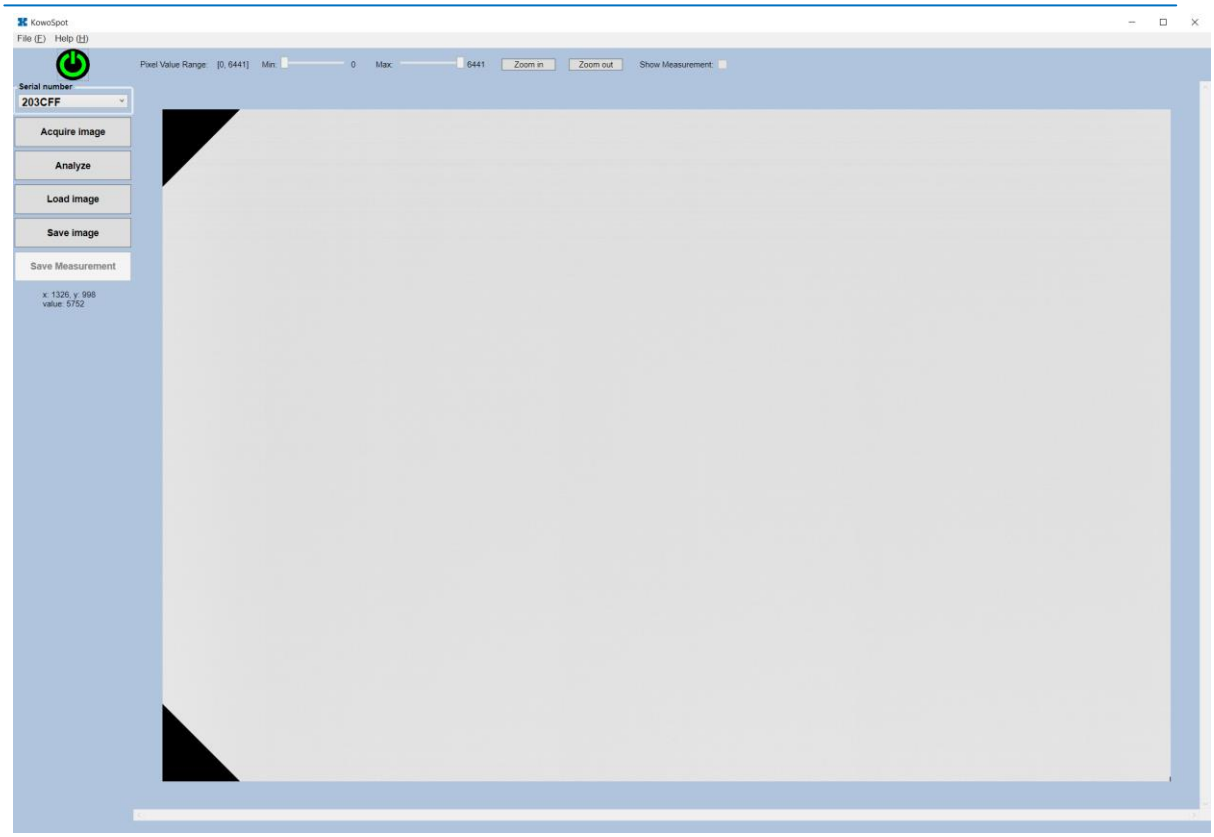


Fig. 3.5: Offset image acquired by the software at startup

3.4 Image Acquisition (3/1)

The software guides you througth the image acquisition. Follow the dialogue from top to bottom.

It starts with an offset image acquisition (if required). There is not check if the X-Ray is OFF during the offset image acquisition. So make sure the X-Ray is OFF. When the offset image acquisition is done, the text in the next lower area is highlighted. Before you start to acquire focal spot images, the X-Ray should be ON.

The tube voltage should be 75% of maximum voltage, the tube current should be the maximum at that voltage.

For longer detector integration time times (>6s) and/or multiple frames (>6) a second offset image after the exposure is recommended because the detector will warm up during exposure and the offset signal will increase.

Of course X-Ray should be turned OFF before the acquisition of the second offset image.

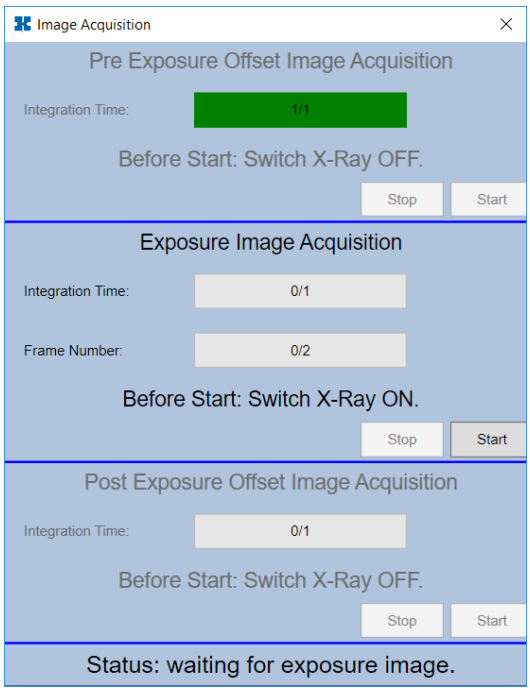


Fig. 3.6: Functions of the Image Acquisition dialog

After pressing the topmost button **Acquire Image** (3/1) on the left side of the main screen, a new dialog to define the image acquisition settings will pop up.

a) After pressing the Start button the software will display the image acquisition dialogue to acquire sample images and compute adapted settings.

b) manual selection of the number of frames which are averaged

c) detector integration time (a longer time gives more signal)

d) forces the software to acquire a new offset image

e) forces the software to acquire a second offset image after all other images and averages the offset.

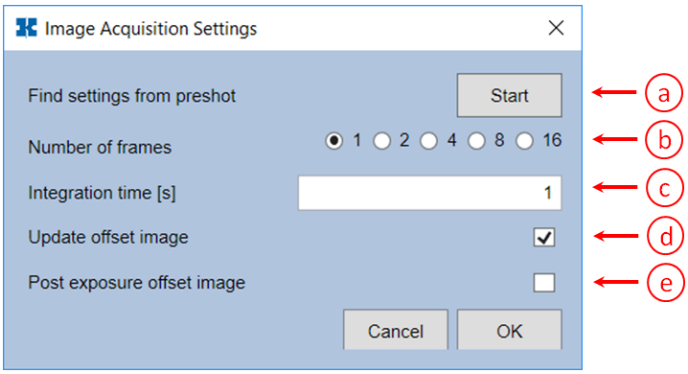


Fig. 3.7: Functions of the Image Acquisition Settings dialog

If you are using the system for the first time, you should use the "Automatic-Mode" (a) by pressing the Start button. With two 2s preshots the signal of the detector will be evaluated and the internal integration time of the detector will be estimated to get a focal spot signal of about 80% of max. signal.

3.4.1 Automatic mode for evaluation of best image acquistion parameters

If you do not know the suitable image acquisition parameters the "*Find settings from preshot*" function to evaluate the best settings shall be used.

Two "test images" with X-Ray ON are acquired and a set of parameters is computed and entered into the Image Acquisition Settings dialogue (see Fig. 3.6).

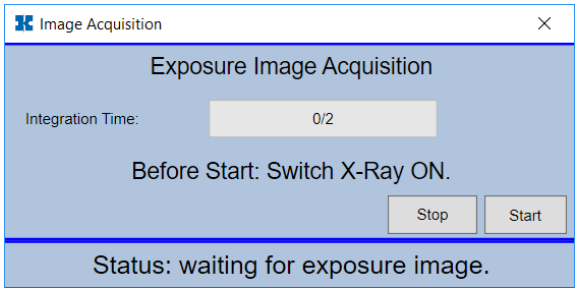


Fig. 3.8: Two exposure images are acquired for the evaluation of the best detector parameters

After this, the new parameters are visible in the previous dialog (compare to Fig. 3.6)

Beside the best detector integration time also the noise in the image is evaluated and the number of frames is set to a value which should ensure that the required SNR of 50 is reached.

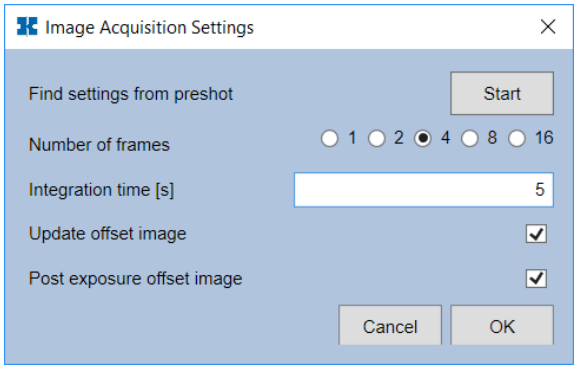


Fig. 3.9: Image Acquisition Settings dialog updated after preshots

If you are familiar with a DSLR you may compare the integration time with the shutter time of your camera and the noise level with the ISO levels (4x longer exposure time = ½ noise level).

3.4.2 During Image Acqistion

During Image Acquisition you should follow the instruction on the screen and assure that the tube is OFF when Offset images are acquired and ON when focal spot images are acquired.

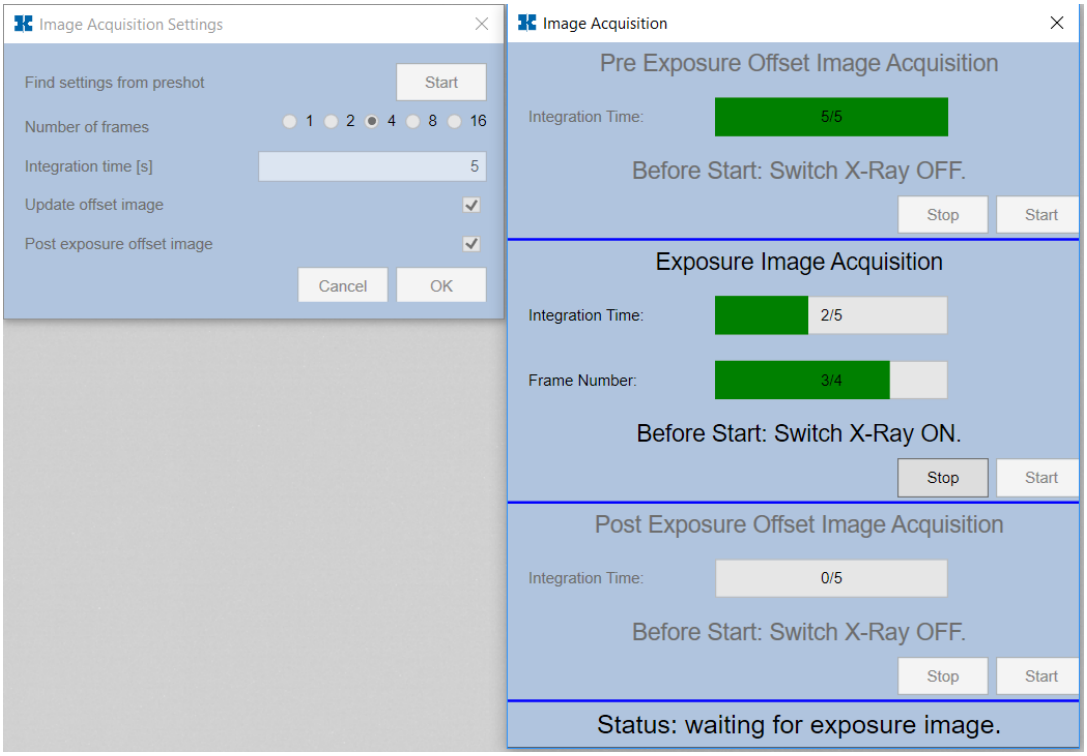


Fig. 3.10: Image Acquisition Settings dialog updated after preshots

When the last image is acquired the dialog will disappear and you will see the focal spot image.

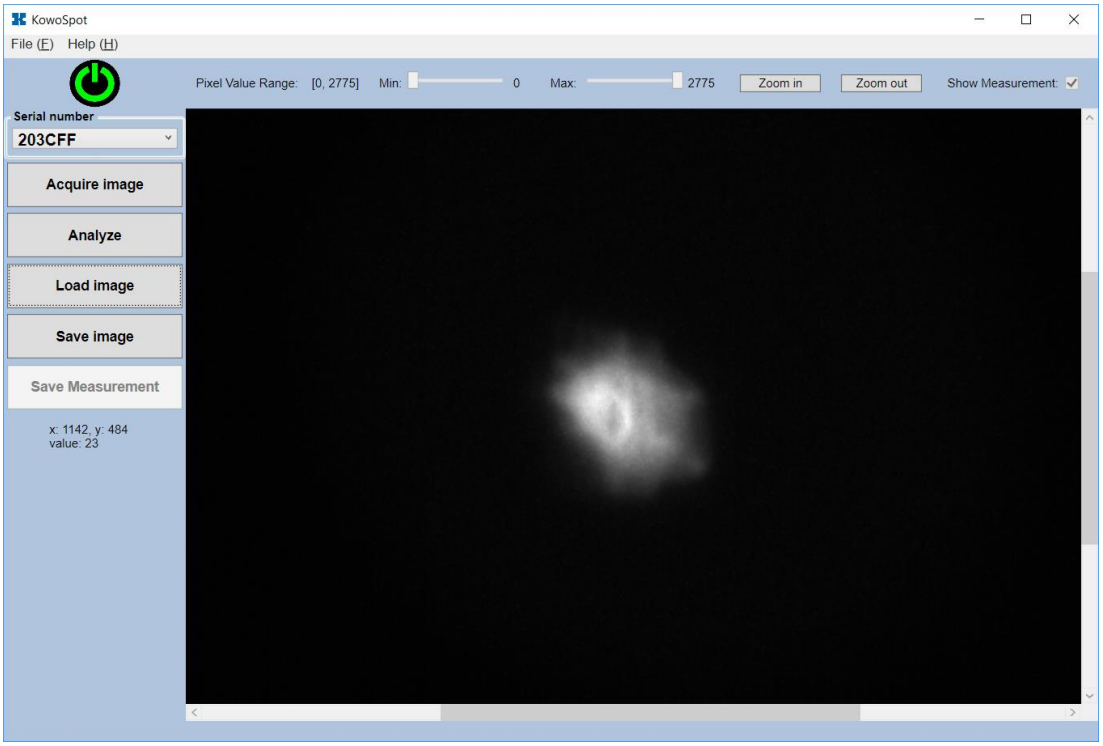


Fig. 3.11: Focal Spot Image with settings from Fig. 3.9

3.5 Analyze the focal spot image with ILP method (ASTM E1165) (3/2)

After pressing the second button **Analyze** (3/2) on the left side of the main screen, a new dialog will pop up to enter the tube parameters and the settings for the focal spot measurement.

Tube Descriptor is the name of the tube.

The tube serial number is required; it should be printed on the tube.

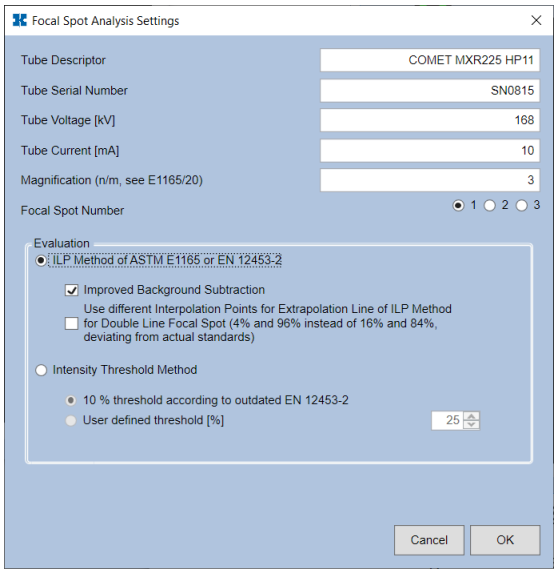
For the tube voltage and current enter the values from your X-Ray control; here for the 225kV tube 168kV and 10mA are used.

The magnification n/m could be taken from Table 2.1 or measured by hand.

Select the ILP method for evaluation (this is the method of the Standards).

For “complicated” focal spot images an Improved Background Subtraction for the ILP method is recommended (see 3.10.2).

Finally select the number of the focal spot which is measured.



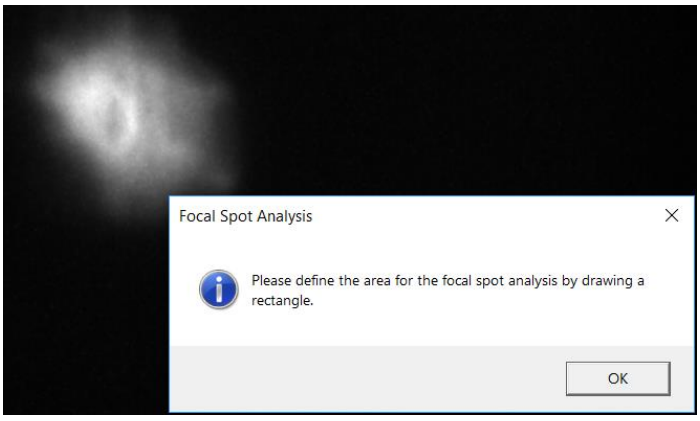
The check box for different interpolation points for the ILP method should only be activated for tubes with old double line foci (see 3.9.3 for details).

Fig. 3.12: Dialog for Focal Spot Analysis Parameters and Settings

When all Settings and Parameters are okay, press the OK button. Then a message box will prompt you to define a region around the active focal spot:

Press OK and move the mouse pointer to the upper left position of the region and draw a rectangle around the focal spot.

The rectangle should be much larger (about factor 3 in both directions) than the anticipated focal spot size.



The drawn rectangle will be shown in green color in the image.

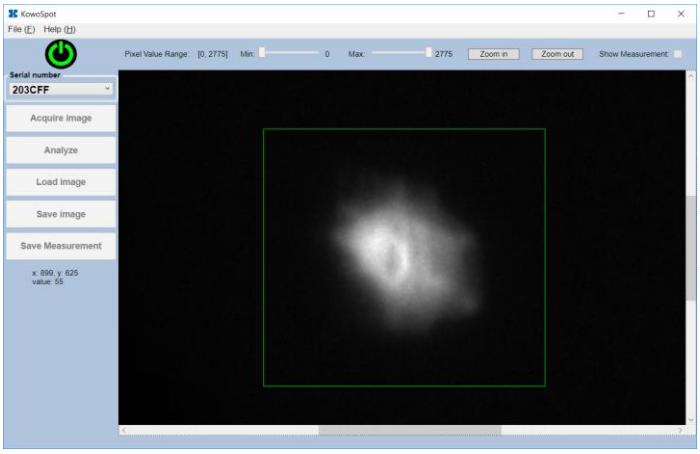


Fig. 3.13: Define the region in the image for focal spot evaluation (see ASTM E1165 for details)

At once the result values are shown in the image; the green rectangle shows the measurement area and the red box the resulting size of the focal spot centered on the focal spot itself. The parameters and the result of focal spot width and length in [mm] and the resulting focal spot class [FS] are printed as an overlay in the image. The "I" in the beginning of the second line indicates that the ILP method was used. In Fig. 3.14 the width is 0.61mm and the length 0.59mm with focal spot class FS9.

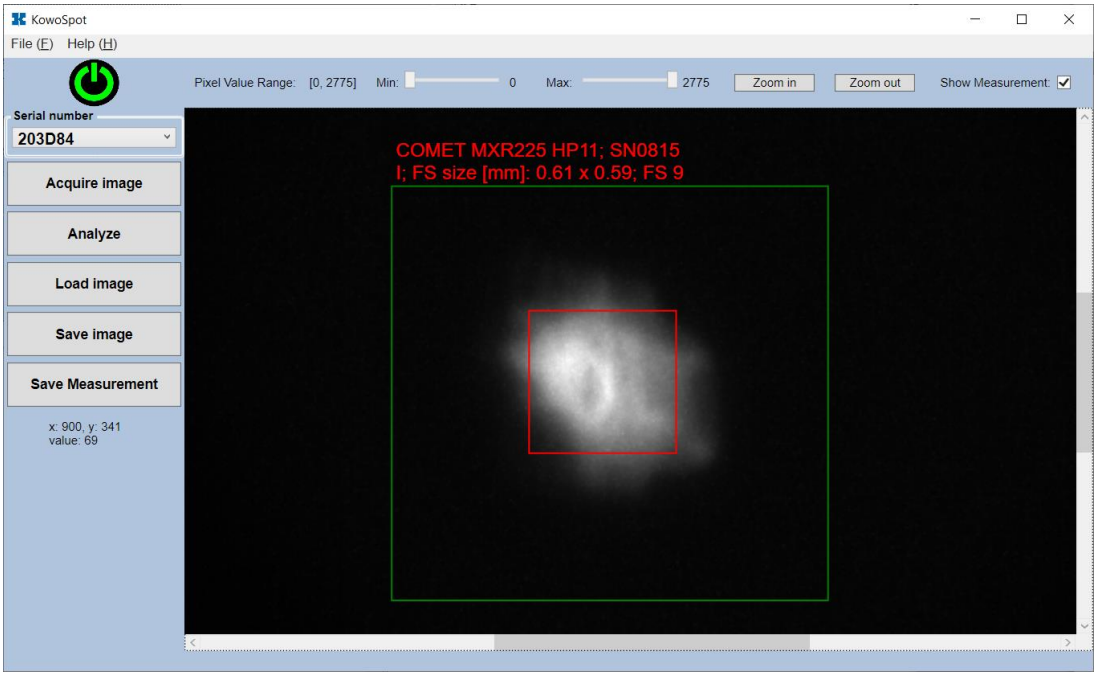


Fig. 3.14: The result of the measurement is displayed in the image

The image without overlay can be inspected if the checkbox "Show Measurement" is deselected.

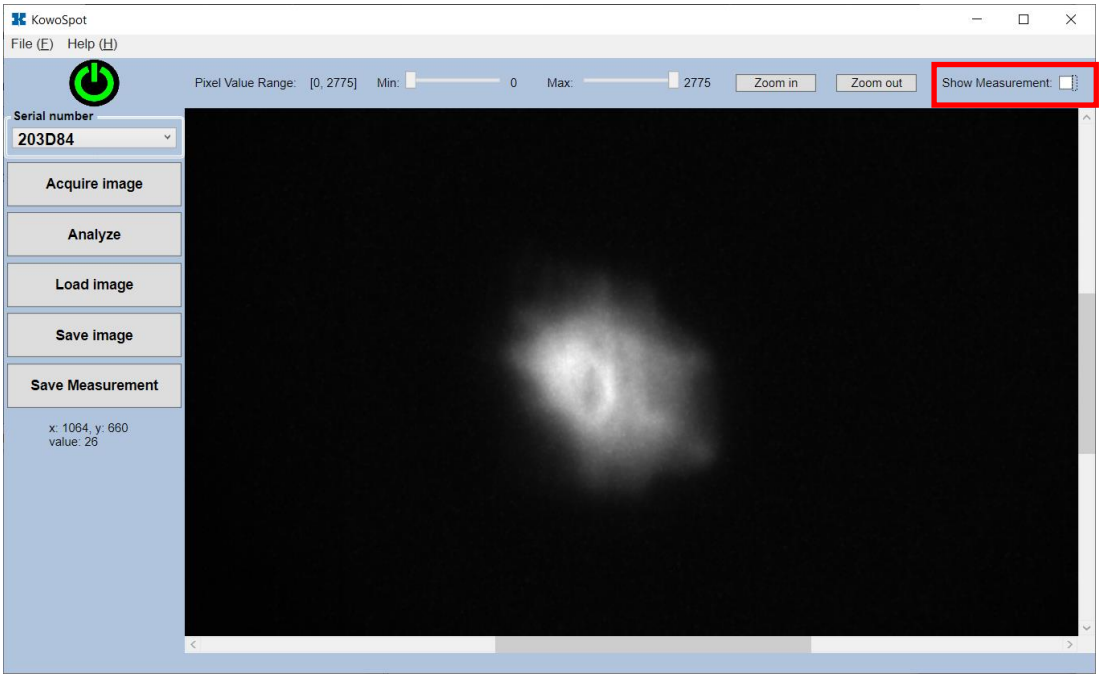


Fig. 3.15: Image without overlay (un-click checkbox "Show Measurement")

To ensure that the method from actual standards is used, the dialog always comes up with the ILP method. If you want another method you have to select it every time when entering the dialog.

3.6 Analyze the focal spot image with the intensity threshold method

KowoSpot 2.3 Software offers also the intensity threshold method which was in the former standards (ASTM E1165 before 2012 and EN12543-2 before 2021) for evaluation of focal spot.

The actual EN12543-2 (2021) is equivalent to the ASTM E1165-2020 evaluation method with the integrated line profiles (ILP).

The software supports users who want to measure with the old 10% intensity threshold method but also developer of X-ray tubes who want the measure with any threshold. In this chapter only the differences to the ILP method are described, the procedure for evaluation is the same.

When the Focal Spot Analysis Settings dialog pops up, the ILP method for evaluation is selected. To use the intensity threshold method you should select the

• *Intensity Threshold Method*

ratio button. Now you could use the 10% threshold from the outdated standard by selecting the radio button

• *10% threshold according to outdated EN12543-2*

or you could go with the threshold you would like to use by selecting the radio button

• *User defined threshold [%]*

and set the value in the box at the end of this line.

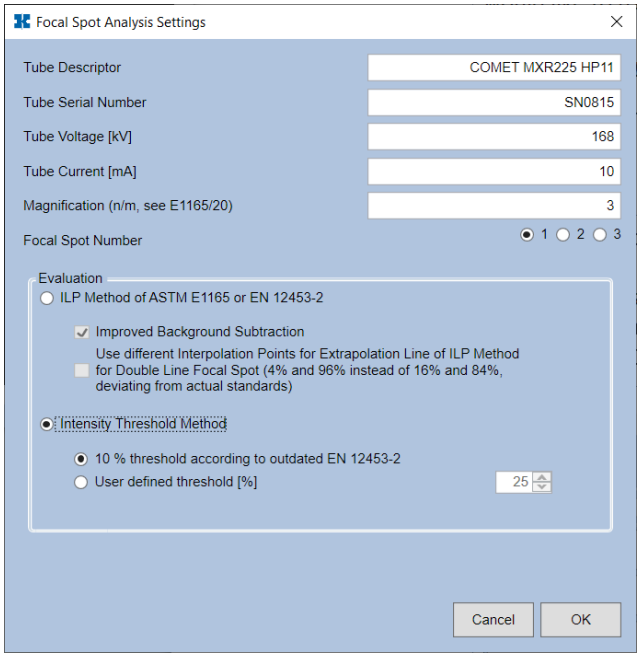


Fig. 3.16: Dialog for Focal Spot Analysis Parameters and Settings with EN12543-2 method selected

When the message box will prompt you to define a region around the active focal spot, press OK and move the mouse pointer to the upper left position of the region and draw a rectangle around the focal spot. Draw a rectangle about two times larger than the focal spot.

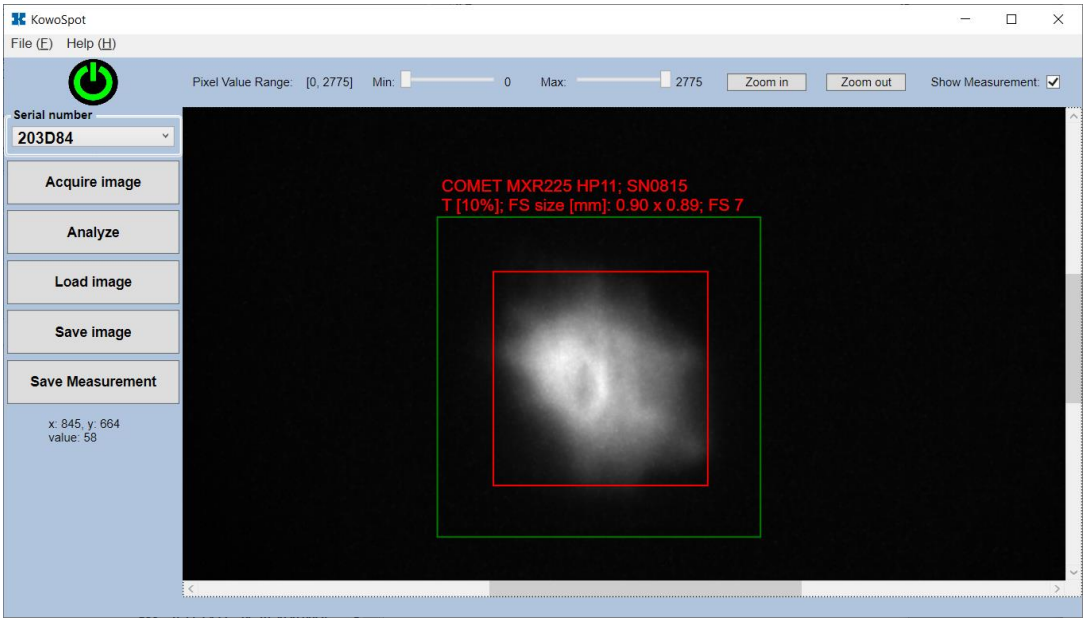


Fig. 3.17: The result of the outdated EN12543-2 10% threshold evaluation is displayed in the image

At once the result values are shown in the image; the green rectangle shows the measurement area and the red box the resulting size of the focal spot centered on the focal spot itself. The parameters, the threshold method and percentage with "*T[10%]*" and the result in [mm] and the resulting focal spot class [FS] are printed as an overlay in the image.

If you compare the results of the 10% method of the outdated EN12543-2 (FS 7) with the results of actual EN12543-2 (or ASTM E1165) ILP method (FS 9) you will notice a difference. The ILP method tends to show the focal spots in the size a digital system would see.

The difference is even larger if the focal spots are shaped not within a central spot:

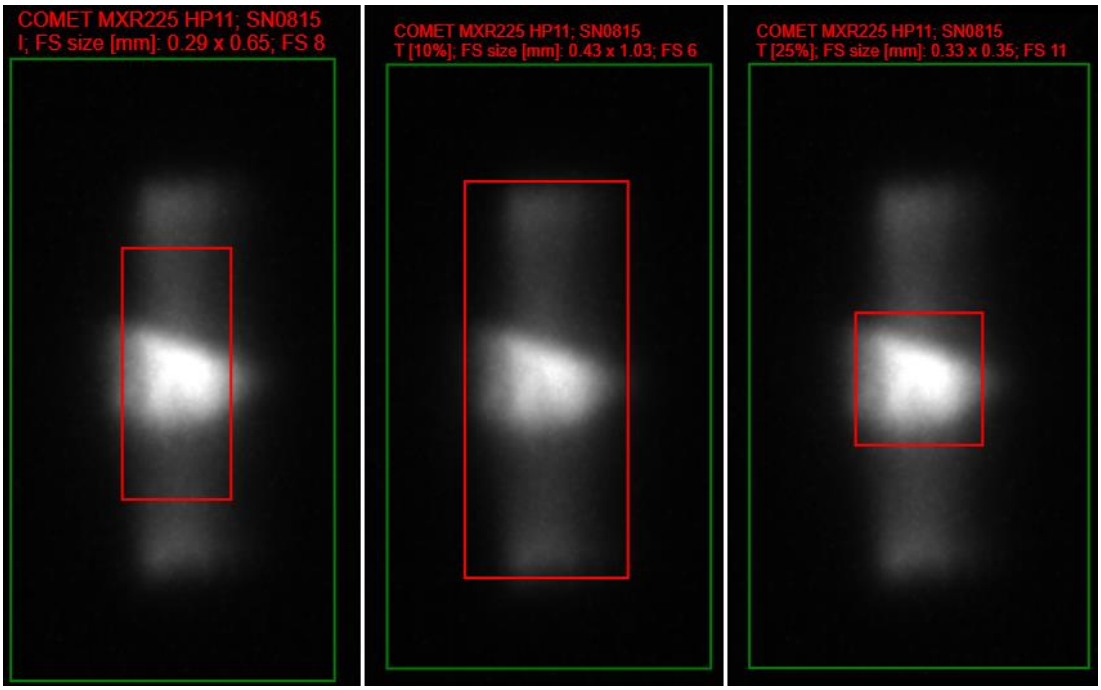


Fig. 3.18: Large difference in results with inhomogeneous focal spots
(ILP left, 10% threshold middle and 25% threshold right)

For development purposes and not conform to the standards a user can select a threshold value from 0 (selected area will be the result) to 70 (results in a very small focal spot).

The software will keep the last selected threshold value for the next evaluation, even after shutdown of the software.

When the dialog "Focal Spot Analysis Setup" is called the ILP method is selected as default. The intensity threshold method has to be selected anytime to ensure that the user is aware that the evaluation is not more conform to the actual standards.

3.7 Save the focal spot image (3/4)

The original image can be saved in lossless 16 Bit TIF Format by pressing the **Save Image** button:

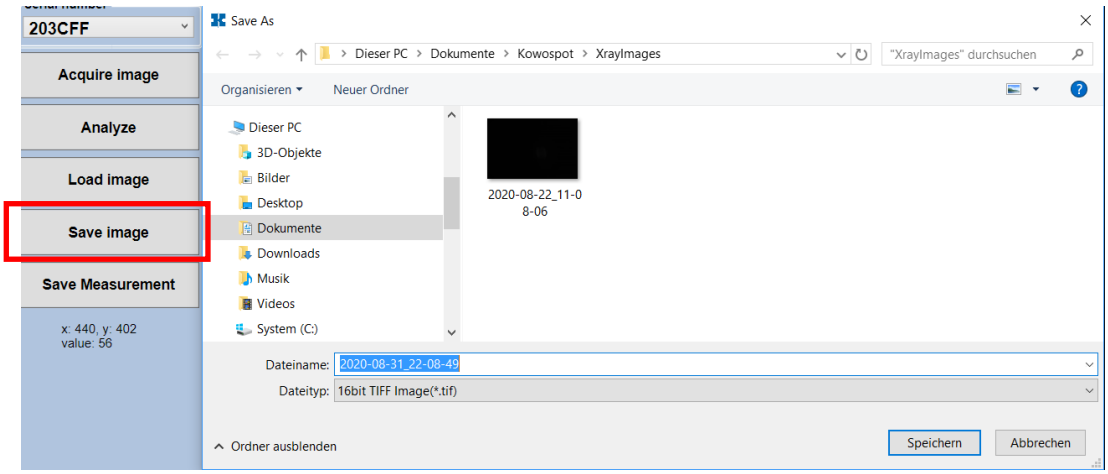


Fig. 3.19: Save image in lossless TIF format

By default the image will be stored in the folder \documents\Kowospot\XrayImages and the proposed name is date and time. You should extend the name or select another name to identify the image for future use.

3.8 Save the measurement results (3/5)

The **Save Measurement** function stores the results in a two level folder structure in \documents\Kowospot\Results. The main folder is named by the serial number of the tube and the subfolder by the actual focal spot number. If you evaluate the same focal spot again later, the new results will be stored in the same folder. This helps the user to review the focal spot sizes over the lifetime of the tube.

The results (original image and result image with overlay) can be saved in lossless 16 Bit TIF Format by pressing the **Save Measurement** button:

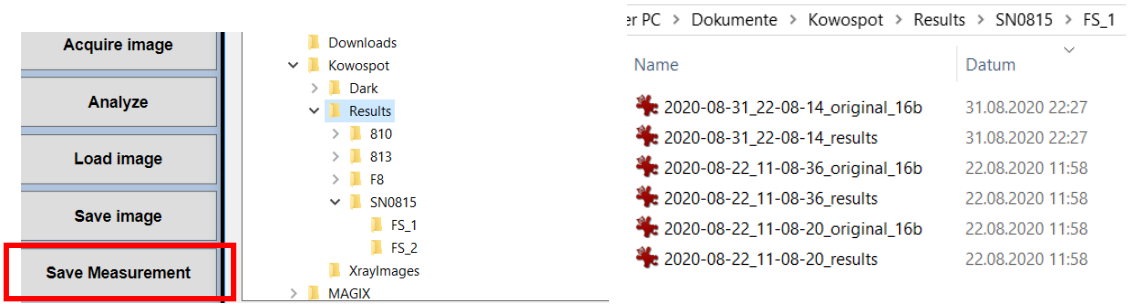


Fig. 3.20: Save results and original image in lossless TIF format

By default the result images (original image and result image with overlay) will be stored in the folder \documents\Kowospot\Results\<Serial Number>\ <Focal Spot Number>.

Additional a protocol file in CVS format (compatible with several spread sheet programs like Excel®) will be stored in the “Results” folder with the name “FSProtocolFile.csv”.

Please note the due to the additional evaluation methods the results files from SW Version 2.x are not compatible with older versions.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Date of Test	Tube Descriptor	Tube Serial Number	Tube Voltage	Tube Current	Focal Spot No	Magnification	Measured Width	Measured Lenght	Reported Width	Reported Lenght	Focal Spot Class	Evaluation Method	Focal Spot SNR	Comment
27.04.2021 11:21	COMET MXR225	SN #116431	168	4,5	2	3	0,427	1,027	0,5	1,27	FS 6	Intensity Threshold	859,724	
27.04.2021 11:22	COMET MXR225	SN #116431	168	4,5	2	3	0,287	0,667	0,32	0,8	FS 8	ASTM 1165	714,25	
27.04.2021 11:23	COMET MXR225	SN #116431	168	10,65	1	3	0,9	0,9	1	1	FS 7	Intensity Threshold	554,157	

As all focal spot measurements are stored in the same file, the sheet can be sorted by the Tube Serial Number (column C) and Focal Spot No. (column F). So the deviation of the focal spot size over time could be seen for all focal spots and tubes contained in the protocol file.

3.9 Load a focal spot image (3/3)

To verify a result or for later evaluation an image can be loaded by the **Load Image** button:

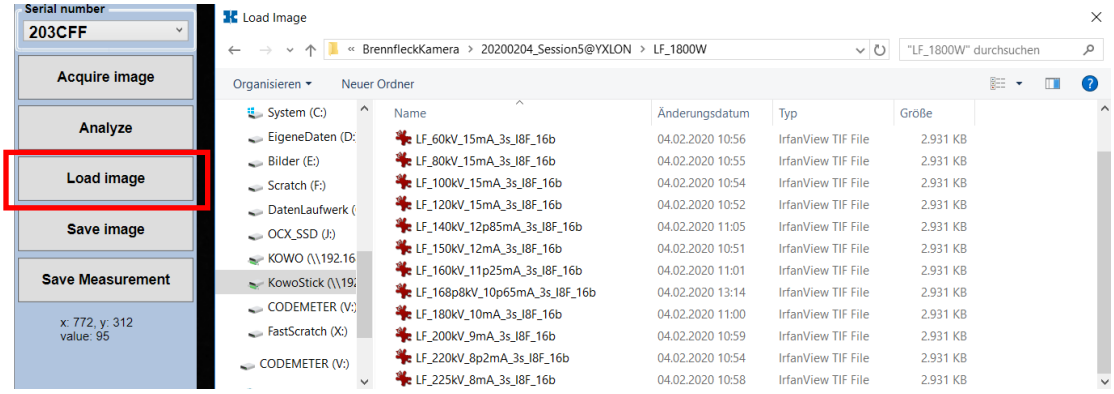


Fig. 3.21: Load image in lossless TIF format

The loaded image can be handled in the same way as an acquired image.

If the image is analyzed again and then stored it would get by default a name with actual date and time. You should pay attention when giving the name to avoid confusion with other images from the same focal spot acquired at a similar time.

3.10 Special features

The KowoSpot software offers some special features to ensure a proper measurement.

3.10.1 Detector Corrections and Bad Pixel handling

Digital Cameras have always an offset. The KowoSpot software acquires offset images and subtracts them from acquired images. As the offset level is time-depended KowoSpot software uses only existing offset images if they are not too old. Also existing offset images are not used if their Integration Time differs from actual image Integration Time.

In these cases a new offset image is acquired be default. Additionally the user can force the KowoSpot software to acquire new offset images (see 3.4)

Most DDAs have underperforming pixel. KowoSpot software detects these under-performing pixels automatically and corrects them before image display without any required user activity.

3.10.2 Improved background subtraction

When using the 10µm pinhole or a larger pinhole with higher energies a penetration of the pinhole element could occur creating a plateau in the image with gradients at the edges (see Fig. 3.22).

A normal background subtraction with a linear interpolation of both ends of the line profile would lead to a much too large result.

For reliable results an iterative process is required. In the KowoSpot software a checkbox for an improved background subtraction is available (see Fig. 3.12). This forces the software to do several steps of optimation of the measurement box size in both directions. A suitable box inside the plateau is identified and the signal of the plateau is removed from the focal spot signal.

With this the KowoSpot camera also be used with higher energies (e.g. 220kV).

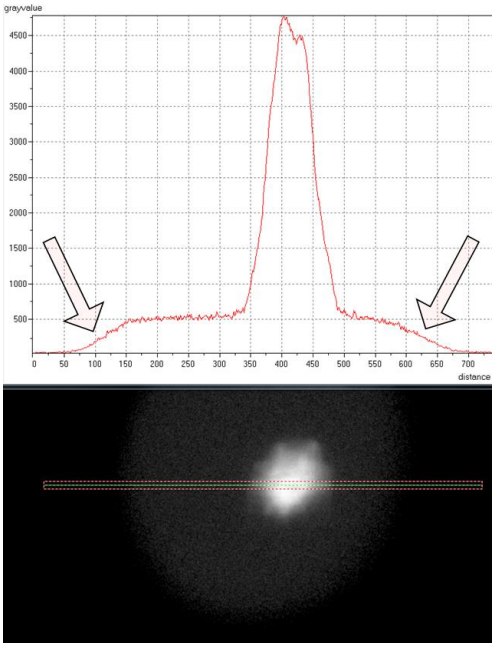


Fig. 3.22: Example of plateau effect

3.10.3 Special handling of large Double Line focal spots

Focal spots with two strong lines at the sides will cause the interpolation through the 16% and 84% value points to give too large results for the computed focal spot size.

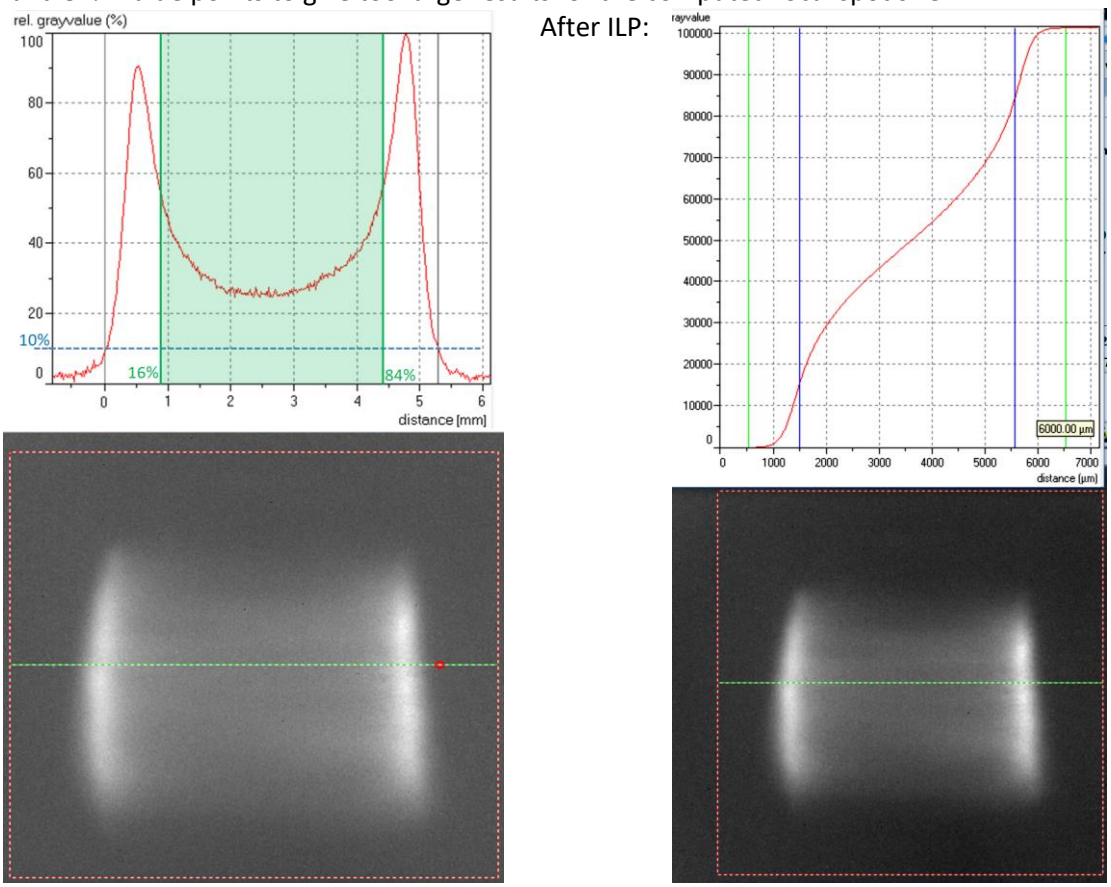


Fig. 3.23: *Double line* focal spots with intensity maxima outside of 16% to 84% area

KowoSpot software offers the option to use different interpolation points for the extrapolation line for Double Line Focal Spot. Instead of 16% and 84%, in deviation from actual standards, the interpolation points will be set to 4% and 96% to get most of the intensity into the evaluation. The result will be much closer to the visual impression:

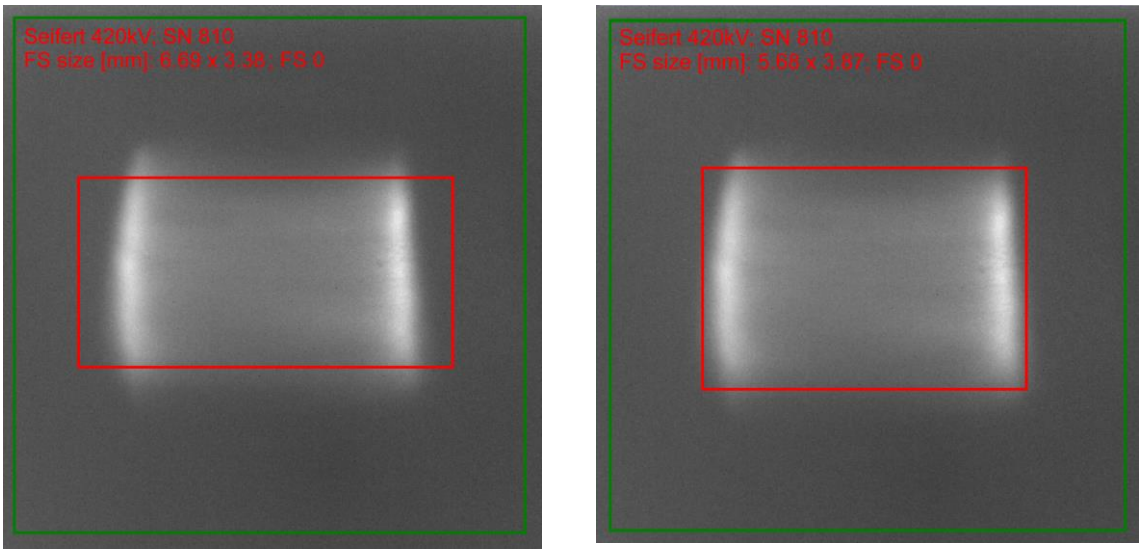
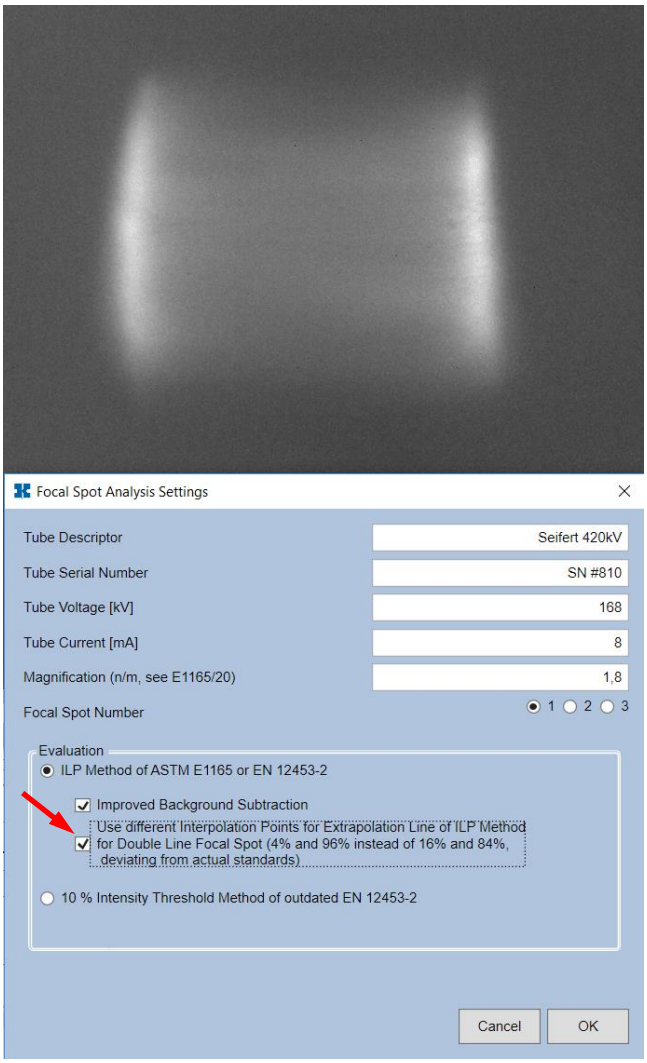


Fig. 3.24: Left: Result with 16% and 84%; right: Result with 4% and 96% interpolation points



To activate these different interpolation points the checkbox marked with the red arrow shall be activated; by default this box is off, it has to be activated every time this function shall be used.

For both directions the same interpolation points are used.

In the result file the usage of these different extended interpolation points is marked in the last column with “true” to show the deviation to the actual standards.

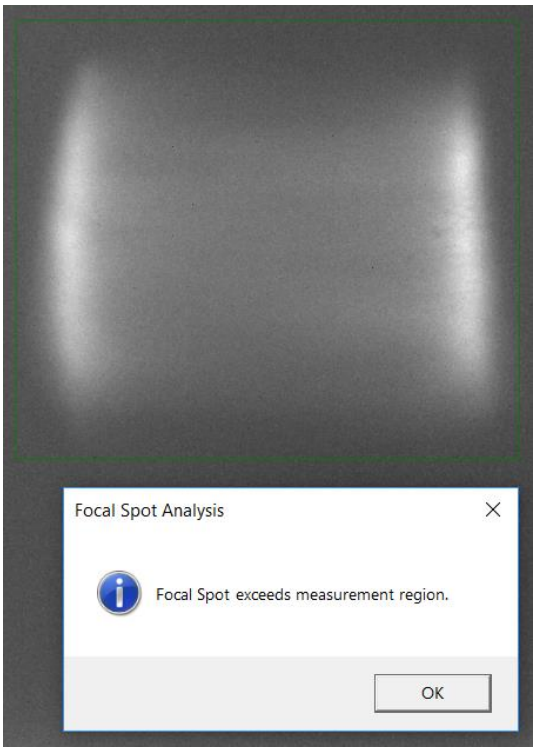
Fig. 3.25: Using the larger evaluation area with 4% and 96% interpolation points

Use this function only, if the result box is much larger than the visual impression of the focal spot. This should only happen when the main intensity is not inside the 16% and 84% area for the ILP function.

Please have in your mind that the 4% and 96% interpolation points deviate from the actual standards and the CEO shall approve the usage of this deviation to the actual standards.

3.11 Special error messages

The rectangle for measurement shall be about three times larger than the anticipated focal spot size (see e.g. ASTM E1165 7.8.1 and Fig. 2a).



If you draw the rectangle smaller it might be even smaller than the real focal spot size.
You will get a warning but you may continue the evaluation.
In the result image you will see the calculated focal spot size outside the measurement region.

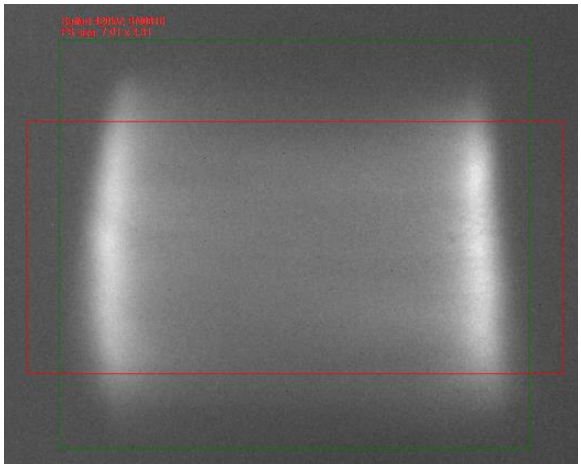


Fig. 3.26: Error Message when measurement region is too small

In every image for analysis the SNR is measured by the KowoSpot SW. According to the standards it should be higher than 50. If the SNR is too low, a message pops up and shows the value of SNR, but you may continue with the evaluation by clicking OK.

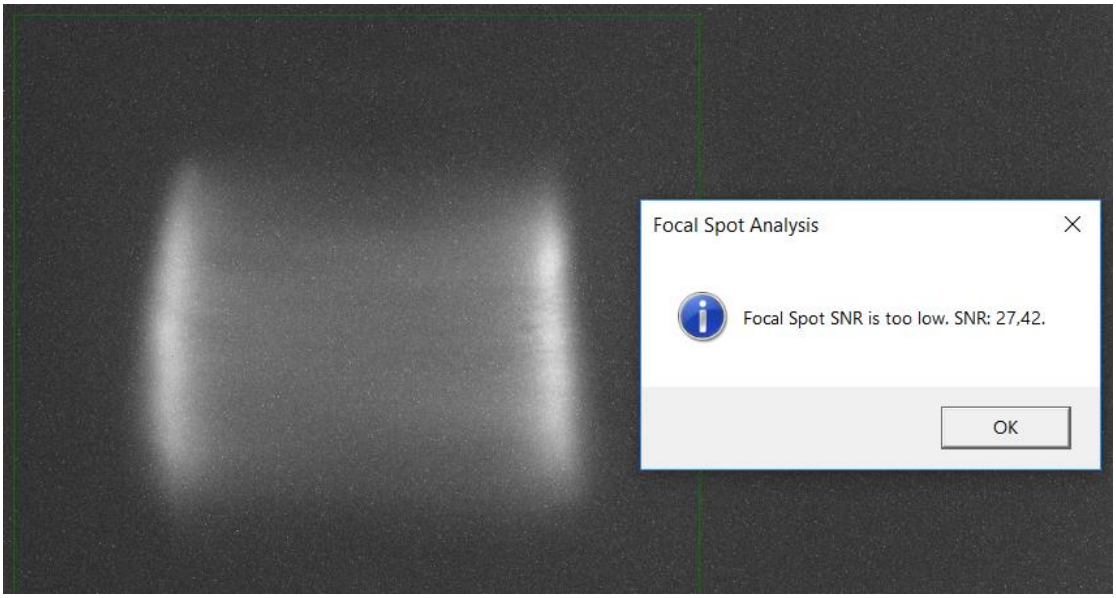
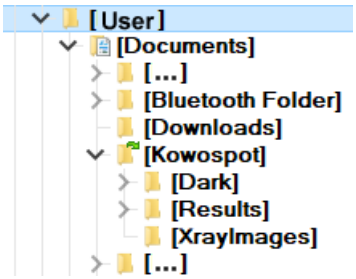


Fig. 3.27: SNR of the Image does not reach the required value of 50

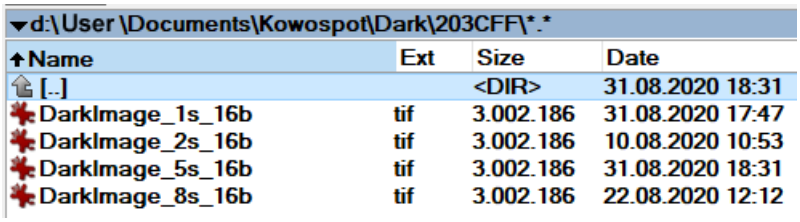
If the SNR is too low, you should follow the hints in chapter 4.4.

3.12 Location of different folders

The default Folder for the offset images (Dark), results (Results) and acquired images (XrayImages) are located in the directory [User \ Documents \ Kowospot]



The folder “Dark” contains the actual acquired offset images for each selected integration time for a single detector, sorted by the integration time.

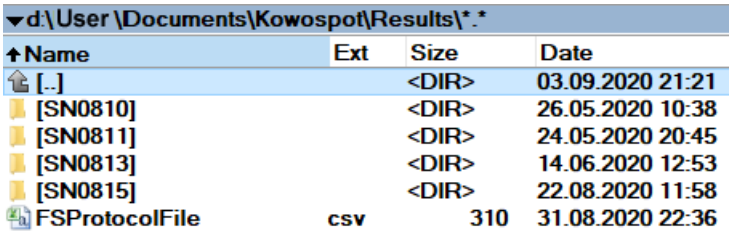


d:\User \Documents\Kowospot\Dark\203CFF*.*

Name	Ext	Size	Date
[..]		<DIR>	31.08.2020 18:31
DarkImage_1s_16b	tif	3.002.186	31.08.2020 17:47
DarkImage_2s_16b	tif	3.002.186	10.08.2020 10:53
DarkImage_5s_16b	tif	3.002.186	31.08.2020 18:31
DarkImage_8s_16b	tif	3.002.186	22.08.2020 12:12

In the example the detector with Serial No. 203CFF was used. Images were acquired with 1, 2, 5, and 8s integration time.

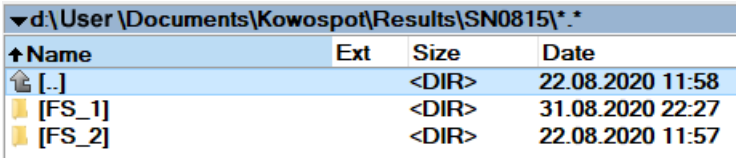
The folder “Results” contains subfolder for the results of the different tubes – named by their serial No.. Additionally the Focal Spot Protocol File (*FSProtocolFile.csv*) is located here.



d:\User \Documents\Kowospot\Results*.*

Name	Ext	Size	Date
[..]		<DIR>	03.09.2020 21:21
[SN0810]		<DIR>	26.05.2020 10:38
[SN0811]		<DIR>	24.05.2020 20:45
[SN0813]		<DIR>	14.06.2020 12:53
[SN0815]		<DIR>	22.08.2020 11:58
FSProtocolFile	csv	310	31.08.2020 22:36

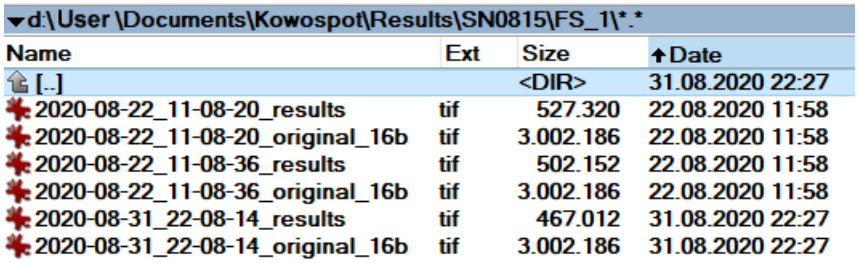
The folder for a tube contains subfolder for the results of the different focal spots of this tube.



d:\User \Documents\Kowospot\Results\SN0815*.*

Name	Ext	Size	Date
[..]		<DIR>	22.08.2020 11:58
[FS_1]		<DIR>	31.08.2020 22:27
[FS_2]		<DIR>	22.08.2020 11:57

In each folder of a focal spot are the original images and the result images (which should be smaller than the original images).



d:\User \Documents\Kowospot\Results\SN0815\FS_1*.*

Name	Ext	Size	Date
[..]		<DIR>	31.08.2020 22:27
2020-08-22_11-08-20_results	tif	527.320	22.08.2020 11:58
2020-08-22_11-08-20_original_16b	tif	3.002.186	22.08.2020 11:58
2020-08-22_11-08-36_results	tif	502.152	22.08.2020 11:58
2020-08-22_11-08-36_original_16b	tif	3.002.186	22.08.2020 11:58
2020-08-31_22-08-14_results	tif	467.012	31.08.2020 22:27
2020-08-31_22-08-14_original_16b	tif	3.002.186	31.08.2020 22:27

3.13 Adjustable parameters

Several parameters could be set. The default values are in brackets.

Internal detector integration time: 0.5s to 16s [2s]
(a larger time gives a higher signal value; range of signal: 0 .. ~4800)

Number of frames 1 to 16 [2]
(noise is reduced with a higher number of frames; E1165: SNR >50)

Force new offset image [no]
(new offset image is recommended after some time of usage)

Post acquisition offset image [no]
(second offset image after acquisition recommended for longer total acquisition time)

Magnification n/m [-]
(this parameter should be set with high precision)

Improved background subtraction [no]
(recommended for larger or “complicated” focal spots or with voltages >200kV)

Evaluation method for focal spot size [a]

(a) ILP method of ASTM E1165 or EN12543-2 (2021)
(b) ILP method of ASTM E1165 or EN12543-2 (2021) with different interpolation points of 4% and 96% instead of 16% and 84%; (recommended only for large double line focal spots – it is a deviation to the standards)
(c) 10% intensity threshold method of outdated EN12543-2 (2008)
(d) user defined threshold for intensity threshold method

4 Improve Image Quality

The KowoSpot Camera is able to deliver superior image quality and measurement results. To get this quality – or a sufficient quality in a shorter time frame – this chapter will give you some advice. More information on ASTM E1165 and the use of the focal spot camera are given in the X-Ray Forum (https://www.x-ray-forum.net).

Before you improve the image quality you should assure that the proper Pinhole Element is installed and that the magnification is as required. For details see Table 2.1 or ASTM E1165-20.

4.1 Correct alignment of the camera to the focal spot

It is essential that the camera is perfectly aligned to the central beam of the focal spot. It is recommended that the collimator is installed; in this case only dose from a cone with an opening angle of 2° will reach the detector .

The KowoSpot Camera shall be moved until the maximum signal from focal spot is nearly in the center of the DDA image (see Fig 3.11).

4.2 Proper Signal Level of the focal spot

When the KowoSpot Camera is aligned to the central beam of the focal spot, the next step is to set the maximum signal of the focal spot to about 4000 grey values (~80% of maximum signal). This can be done with an adapted detector integration time .

It is recommended to use the automatic "*Find settings from preshot*" function (see 3.4.1). Alternatively you could acquire an image with 2s detector integration time and measure the maximum signal level in the image (The pixel value range is displayed right beside the detector start button (2) (see 3.1)).

In most cases the signal is below a pixel value of 4000. To get a suitable detector integration time you may use the formula

$$t_{(\text{detector integration time})}[s] = 2s * PV_{(max,\ shall)} / PV_{(max,\ measured)}$$

with $PV_{(max,\ measured)}$ the maximum Pixel Value of the 2s image and $PV_{(max,\ shall)}$ the maximum Pixel Value which shall be reached. For the KowoSpot Camera this value is in the range of 3500 to 4000. The maximum Pixel Value shall not be greater than 4000. Select a detector integration time without decimal point (e.g. 5s and not 5.4s) to avoid too many offset images (the KowoSpot software will create a separate offset-image for each detector integration time).

In the unusual case of a Pixel Value above 4000 for the 2s detector integration time image you should repeat the exposure with 1s detector integration time. If the maximum Pixel Value is below 4000, you may use 1s for your measurements (or may increase to 1.5s). If the maximum Pixel Value is still above 4000 (what we never observed), you should repeat the test with shorter detector integration times until the maximum pixel value is below 4000.

You should pay attention to the image if there is an outliner (overperforming pixel) who could produce such a high pixel value – and you should have a look if the pinhole is installed in the pinhole element.

4.3 High Background Signal Level

A high background signal reduces the dynamic range of the focal spot image and the SNR. Because the DDA of the KowoSpot Camera has a good contrast and high dynamic range background values of 1000 and more may be acceptable if the required SNR is achieved.

According to our experience the background signal is mainly a scatter signal from the elements behind the pinhole element. Inside these elements the new KowoSpot Cameras are equipped with a scatter protection made of brass– check if it is installed. Additionally the collimator reduces the background signal by factor of two.

If the scatter protection and the collimator are installed and the background signal is still too high, check if the offset values have changed since the last offset image was acquired. Switch OFF the tube and acquire an image with same parameters as before. If the value is still very high now, you should acquire offset images before and after the test image. Click both checkboxes for the offset images ON (see Fig. 3.10).

If this still leads to an unusual high background value you should try to reduce the kV of the tube.

4.4 Improve **S**ignal to **N**oise **R**atio (SNR)

Low Pixel Values of the focal spot normally result in a low **S**ignal to **N**oise **R**atio. Longer exposure times increase the noise level. With the frame averaging function of the KowoSpot software, the noise can be reduced significantly. An image with four frames has just half the noise compared to a single frame image. An image with 16 frames at same conditions has only ¼ of the noise of the single frame image. ASTM E1165 requires a SNR of 50 or more. If your image does not reach the **S**ignal to **N**oise **R**atio of 50 you will get a warning but may proceed with the measurement and get a result.

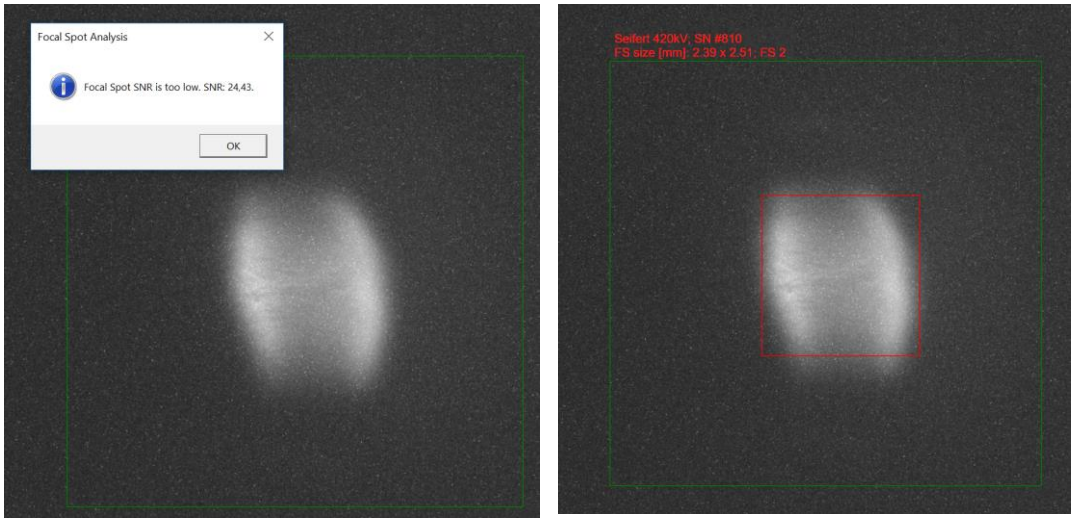


Fig. 4.1: Warning for low SNR and resulting image

With a lower SNR than 50 your result is not more conform to ASTM E1165.

You should try to increase the number of frames for averaging or, if the max pixel values of the focal spot image are well below 4000, you should try to increase the tube current. For this example, a tube with a 2.5mm focal spot, 4mA was used – the maximum would be 10mA. In the example the SNR is 39.5 (printed in *FSProtocolFile.csv*). With 6.4 mA the required SNR of 50 would be reached.
A third option would be to use a pinhole with a larger diameter – if possible (see Table 2.1).

4.5 Usage with higher energies (>>200kV)

The KowoSpot camera is optimized for energies up to 200kV. It may also be used with higher energies (see ASTM E1165-20). With higher energies the pinhole will be penetrated by the higher energy photons and this will create a plateau in the image (see Fig. 4.2). As pinholes cannot be made with larger wall thicknesses, this physically effect has to be accepted. This effect is well visible at 450kV:

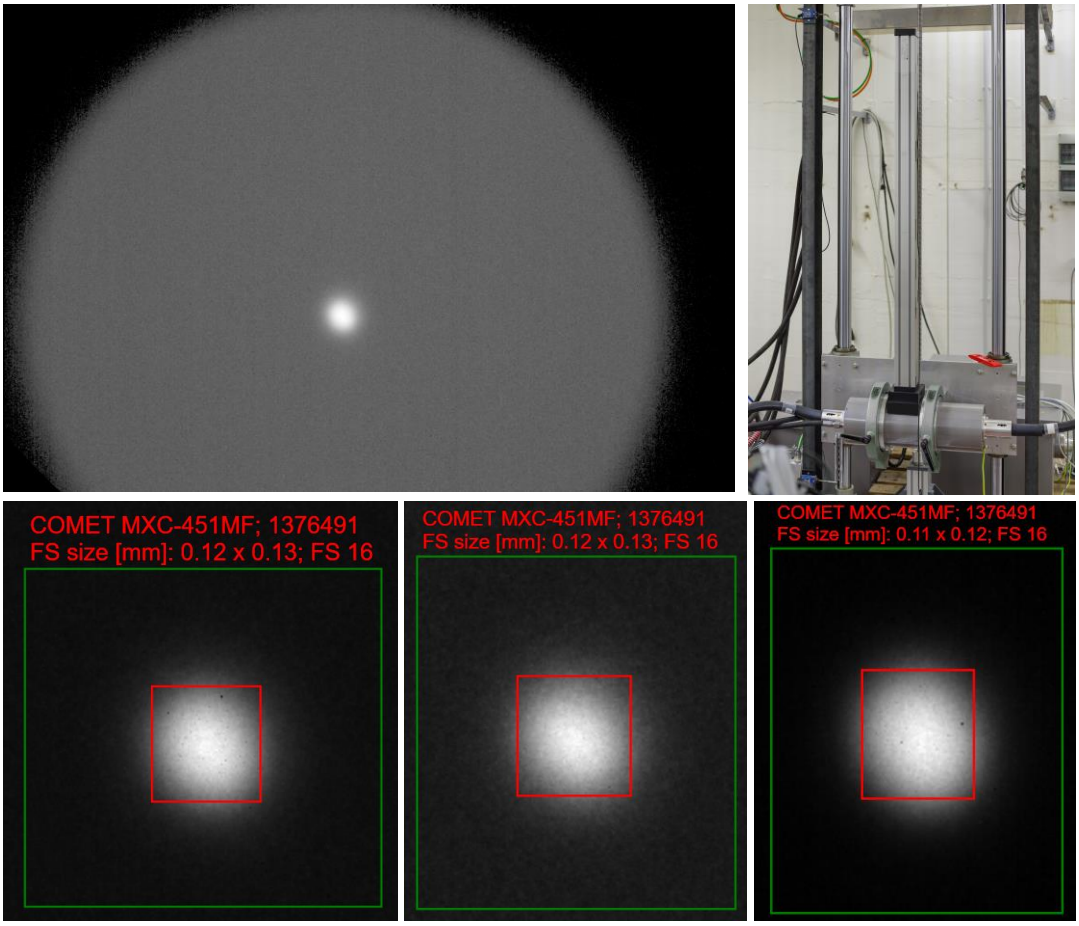


Fig. 4.2: Kowospot image of a 130µm focal spot at 450kV with magnification 9 and focal spot results at 450kV, 338kV and 100kV (from left to right)

When the magnification is large enough the area of the signal of the penetrated pinhole is large enough to avoid that the area for evaluation will get in the range of the edge of the penetrated pinhole signal.

The KowoSpot software offers an improved background subtraction to reduce the influence of the plateau in the image (see 3.10.2). The second row in Fig. 4.2 shows the very small influence of the used energy on the results.

4.6 Handling of quite small focal spots

Small focal spots (<0.4mm) have a high dose density which means that the dose per square millimeter is higher than from larger focal spots.

When measuring small focal spots you should
- select a suitable pinhole (the B10µm element)
- increase the magnification to in minimum the value given in Table 2.1 (more is better)
- start with an detector integration time of one second to avoid saturation.

4.7 Handling of focal spots with “satellites”

Small focal spots from tubes with a steep target angle (e.g.11°) tend to have satellites.
The line profile on the right shows a signal of about 30% of the central signal at both sides of the central focal spot.
Additionally a plateau from the penetration of the pinhole itself is visible.
For such focal spots the improved background subtraction shall be used.

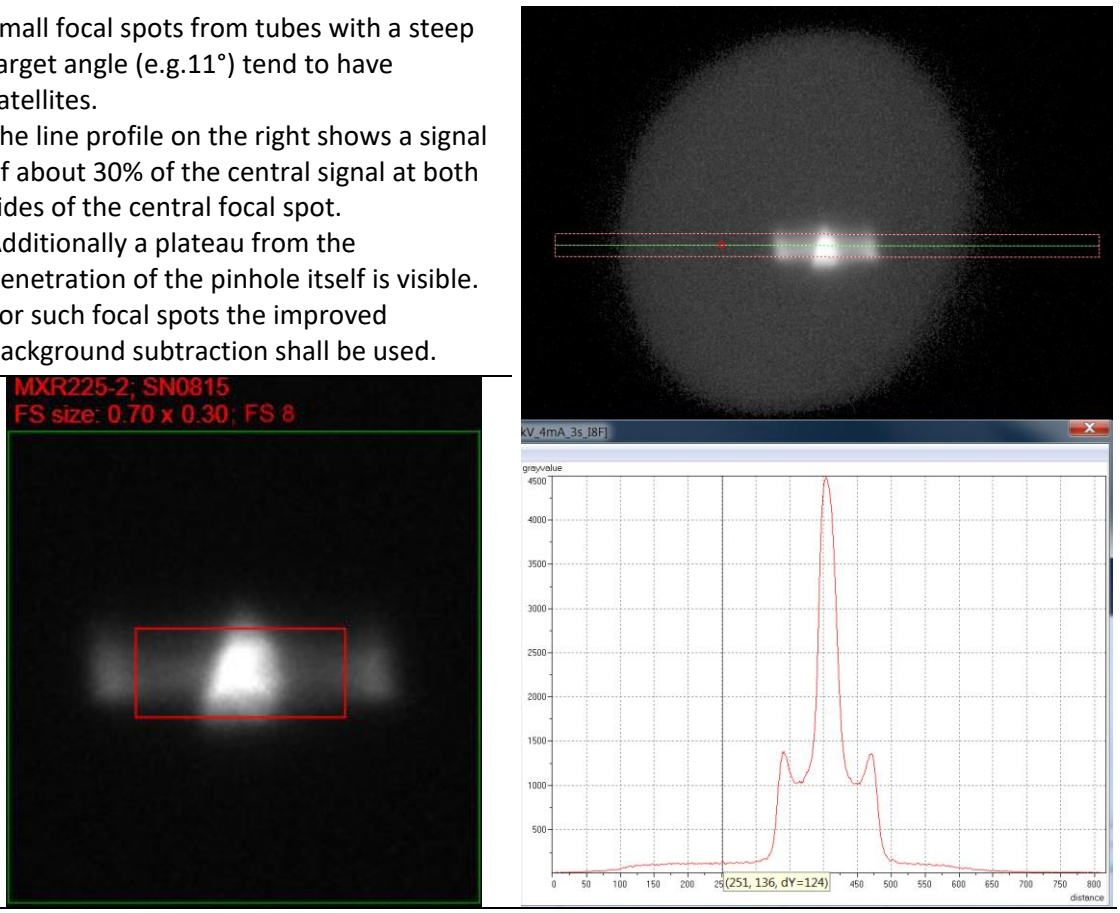


Fig. 4.2: Improved background subtraction for non-uniform focal spots

The improved background subtraction optimizes the region for evaluation by an iterative process to get rid of gradients or plateau around the focal spot in the image. Sometimes it is helpful to try an evaluation with and without the improved background subtraction and visually compare the results.

4.8 Special handling of very large focal spots

Very large focal spots (>3mm) have a low dose density which means that the dose per square millimeter is lower than from smaller focal spots.

When measuring larger focal spots you should
- select a suitable pinhole (mainly the B100µm element – see Table 2.1)
- increase the detector integration time to get sufficient signal
- increase the number of frames for averaging to get a good SNR
- use the offset images before and after exposure to compensate the offset drift.

The offset signal increases with detector integration time and temperature. Within a longer session the offset signal will be higher than in the beginning of the session as the detector warms up during operation. Therefore a reacquire of the offset images is recommended – especially when the number of frames is high and the detector integration time long.

5 Installation of the Software

The KowoSpot Software comes on a USB Stick. You will find the following folders on the Stick
- DetectorDriver
- KowoSpot
- Documentation

If you have a previous version of the KowoSpot software on your computer it should be removed with the standard Windows® Program function *Apps & Features*. Your parameters and settings will stay if you install the new version in the same folders.

5.1 System Requirements

The recommended computer environment is the following

CPU:	Intel Core i5-2520M 2.5 GHz or better
Memory:	4 GB or more
OS:	Windows 10 64 Bit (Windows 7 on request)
Interface:	USB 3.0 (USB 2.0 with restrictions)

Trademarks:

Windows 7 and Windows 10 are the registered trademarks or trademarks of Microsoft Corporation in the United States and other countries.
Other brand names are the trademarks or registered trademarks of each company.

5.2 Installation of the Detector Driver

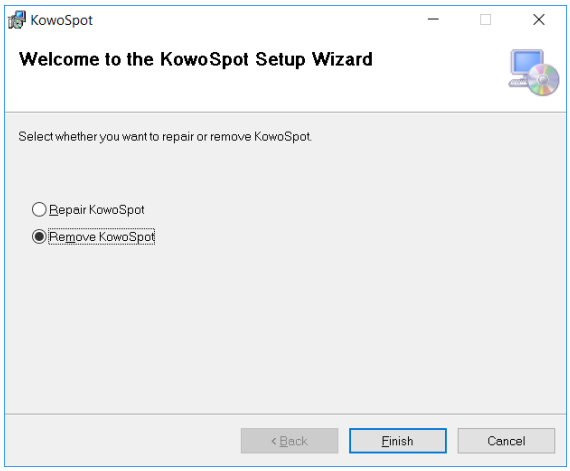
First the detector driver has to be installed. The detector shall not be plugged in to the PC; if it does, disconnect the detector from the PC before installing the detector driver.

1. Start the installer program with a double click on
   DriverSetup_64bit.exe
   in the folder /DetectorDriver/ on the USB stick.
2. Click **Yes** if prompted by the Windows User Account Controls.
3. Make sure that the detector is not connected and click **Yes**.
4. Click **Next** to begin the installation.
5. Follow the instructions on each installation page.
6. Click **Install** if prompted by Windows Security.

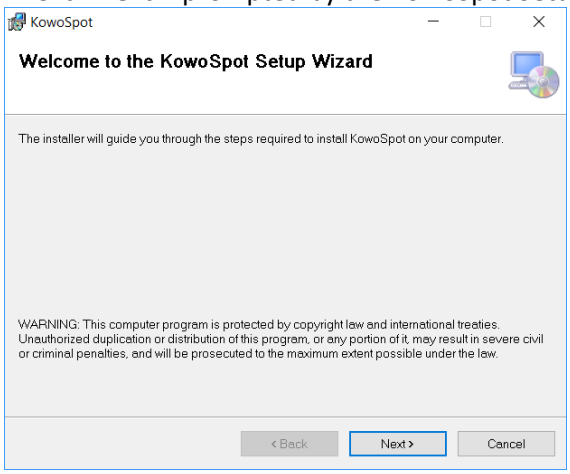
5.3 Installation of the KowoSpot Software

1. Start the installer program of KowoSpot software with a double click on **KowoSpotInstaller.msi** in the folder / KowoSpotSoftware/ on the USB stick.

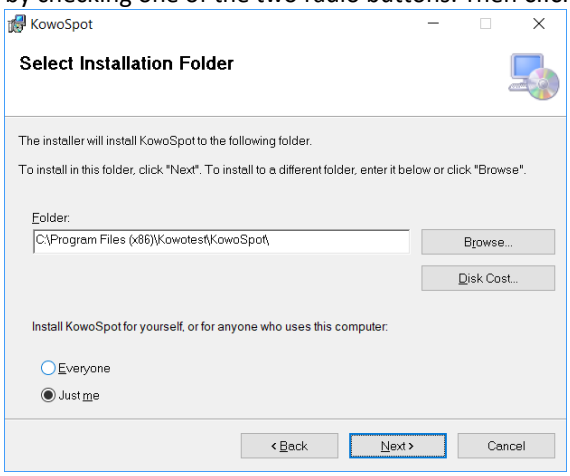
If you have a previous version of the KowoSpot software on your computer it should be removed before installing the new version.



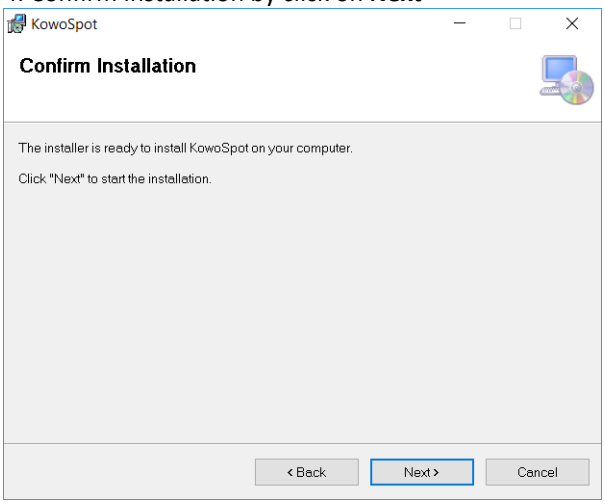
2. Click **Next** if prompted by the KowoSpot Setup Wizard.



3. Select the Installation Folder (the recommended folder is already selected, but you may select a different one with click on **Browse**). Select if the software should be used by **Everyone** or **Just you** by checking one of the two radio buttons. Then click **Next**.

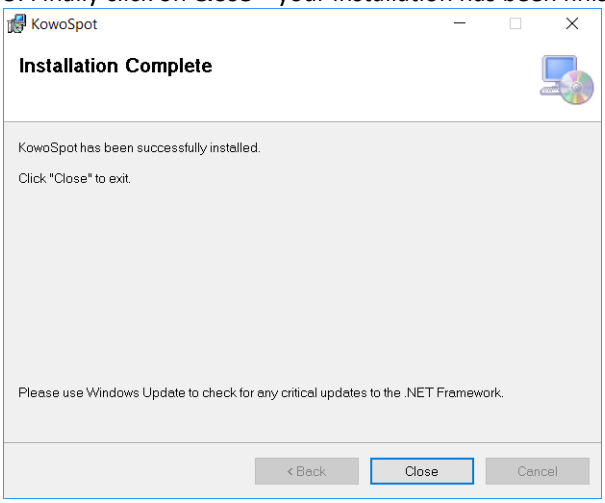


4. Confirm Installation by click on **Next**

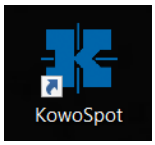


If you started the installation without administrator rights you will have to give a password for an account with administrator rights.

5. Finally click on **Close** – your installation has been finished



and you will find the KowoSpot Software Icon on your desktop:



If you install the KowoSpot software on a computer with WIN7® or WIN8.x® you might have to update the Microsoft ® DOTNET to an actual release of the Runtime Framework.

6 Technical Data

The KowoSpot Software is delivered on an USB Stick. You will find the following folders on the Stick
- DetectorDriver
- KowoSpotSoftware
- Documentation

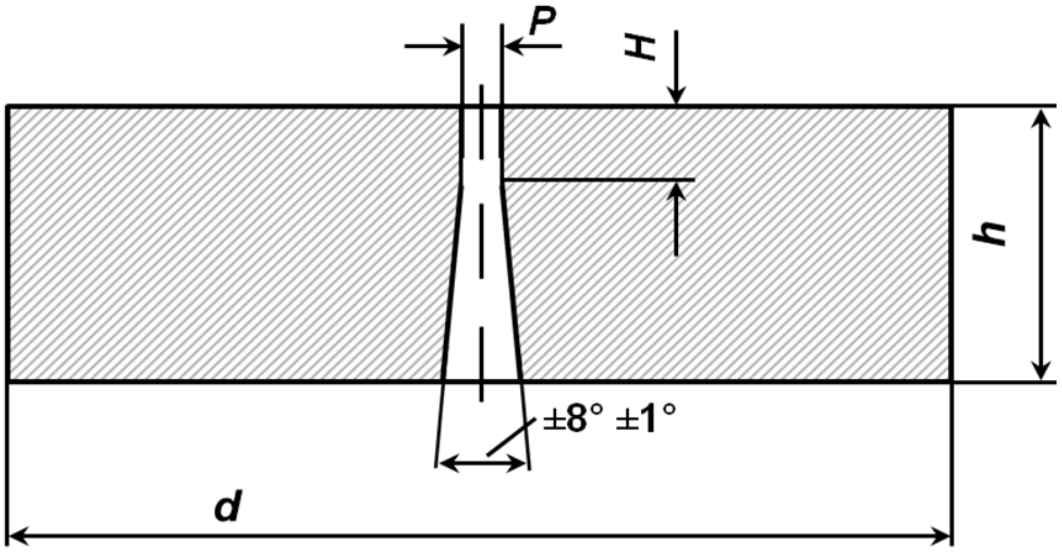
6.1 Technical Data of Camera Hardware

See Chapter 2.1 and Table 2.1 for description of the elements.

	Focal Spot Size		Pinhole	Magnification	Tube head	Configuration				
Part No.	EN 12543-2	ASTM E1165	Element	n/m	Adapter (opt.)	Pos 2	Pos 3	Pos 4	Pos 5	Pos 6
11 01021	> 2mm	> 3.2mm	100µm	1:1	AD	V1	B100	V1		D
11 01022	> 2mm		100µm	2:1	AD	V1	V1	B100	V2	D
11 01023	1.0 .. 2.0mm	1.6 .. 3.2mm	100µm	3:1	AD	B100	V1	V1		D
11 01024	1.0 .. 2.0mm		100µm	4:1	AD	B100	V1	V1	V1	D
11 01025	0.3 .. 1.0mm	0.5 .. 1.6mm	30µm	3:1	AD	B30	V1	V1		D
11 01026	0.3 .. 1.0mm		30µm	4:1	AD	B30	V1	V1	V1	D
11 01027	0.1 .. 0.3mm	0.32 .. 0.5mm	10µm	3:1	AD	B10	V1	V1		D
11 01028	0.3 .. 1.0mm	0.25mm	10µm	4:1	AD	B10	V1	V1	V1	D

Table 6.1: Configurations of KOWOSPOT X for different Focal Spot Sizes; grey lines are non-standard

6.2 Technical Data of different Pinholes

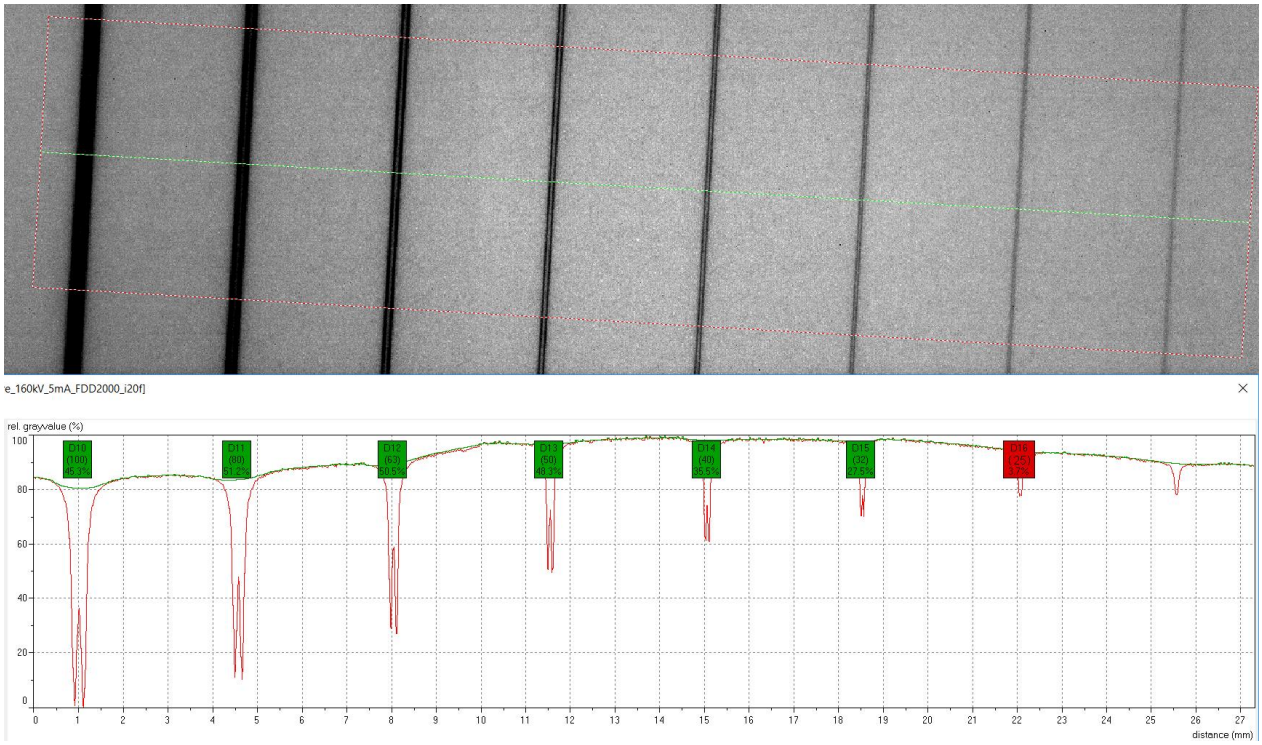


	Diameter **P**		Height **H**		Diameter **d**		Height **h**	
	[µm]	tolerance [µm]	[µm]	tolerance [µm]	[mm]	tolerance [mm]	[mm]	tolerance [mm]
in B10	10	± 5	20	± 10	5	± 0.10	1.5	± 0.05
in B30	30	± 5	75	± 10	5	± 0.10	1.5	± 0.05
in B100	100	± 5	500	± 10	5	± 0.10	1.5	± 0.05

Material: Gold-Platinum – 90/10% [Au / Pt – 90/10]

6.3 Technical Data of the KowoSpot Detector

Parameter	KowoSpot	Unit
Image Size (H x V)	20 x 30	mm
Pixel Pitch	20	µm
Basic Spatial Resolution ($SR_b^{detector}$)	25	µm
interpolated Basic Spatial Resolution ($iSR_b^{detector}$)	30.5	µm
Dynamic Range	57	dB
Number of effective Pixels	1000 x 1500	pixels
Scintillator Type	CsI (Tl)	
Interface	USB 2.0	



Example with a sample detector: The duplex wire #15 (32µm) is resolved with 27.5%, #16 (25µm) with 3.7%, giving a $SR_b^{detector}$ of 25µm (first Duplex Wire Pair with less than 20% dip) and an interpolated $iSR_b^{detector}$ of 30.5µm. For details refer to ASTM E2002-21.

Absolute maximum ratings

Parameter	Condition	Min.	Max.	Unit
Operating Temperature	No dew Condensation *1	0	35	°C
Operating Humidity	No dew Condensation *1		70	%
Operating Pressure		700	1060	hPa
Storage Temperature	No dew Condensation *1	-20	70	°C
Storage Humidity	No dew Condensation *1		70	%
Storage Pressure		700	1060	hPa
Energy Range		60	340	kVp
Reliability (typical)	100µGy/shot, 160kV, no filter		4000	shots

*1: When there is a temperature difference between a product and surrounding area in high humidity environment, dew condensation may occur at the product surface. Dew condensation on the product may cause deterioration in the characteristics and reliability.

6.4 Technical Data of Software

- Focal Spot measurement as required in ASTM E1165 or EN12543-2 with the pinhole method
- Performs Integrated Line Profile function (ILP) as required in ASTM E1165 or EN12543-2 in a one-step procedure
- Performs the 20% threshold method of EN12543-2 (2008) in a one-step procedure
- Supports DDA with 20µm pixel pitch and calculates the effective system pixel size with a precision of 1% of the anticipated focal spot size
- Supports automatic offset correction
- Guides user through measurement procedure
- Built-in Despeckle filter for outliers
- Stores images in 16 Bit TIF format (lossless)
- Stores result images with overlay in TIF format and numerical results in a result file in CSV format which can be used in spreadsheets
- Record in CSV format contains focal spot sizes (X/Y), focal spot class and SNR value
- Background subtraction with linear interpolation of both ends of the line profile
- Improved background subtraction with iterative steps for background detection and removal
- Special handling of large double line focal spots with different interpolation points
- Option to load focal spot images and do offline evaluation

6.5 CE conformity declaration

Konformitätserklärung / Declaration of Conformity

EG-Konformitätserklärung nach EN ISO/IEC 17050-1/-2:2004

EC Declaration of Conformity according to EN ISO/IEC 17050-1/-2:2004

Mit dieser Konformitätserklärung erklärt der Hersteller

With this Declaration of Conformity it is confirmed by the manufacturer

KOWOTEST Gesellschaft für Prüfausrüstung mbH
Solinger Strasse 186, 40764 Langenfeld, Deutschland / Germany
Telefon / phone: +49 2173-22383

dass die Produkte

that products

Bezeichnung
KOWOSPOT X

description
KOWOSPOT X

Maschinentyp
Lochkamera zur Brennfleckgrössenbestimmung

machine type
Pin Hole Camera for measurement of Focal Spot

Modell Nr.
KOWOSPOT X mit CMOS Detektor, Software

model no.
KOWOSPOT X with CMOS Detektor, Software

Code Nr.
11 01021, ...22, ...23, ...24, ...25, ...26, ...27, 11 01028

code no.
11 01021, ...22, ...23, ...24, ...25, ...26, ...27, 11 01028

in Übereinstimmung mit der EG-Niederspannungs-richtlinie 2014/35/EU : 20.04.2016 und der Elektromagnetischen Verträglichkeitsrichtlinie 2014/35/EU : 20.04.2016, sowie den nachfolgend genannten Normen und Richtlinien hergestellt worden sind:

are manufactured in accordance to EC Low Voltage Directive 2014/35/EU : 20.04.2016 and Electromagnetic Compability Directive 2014/35/EU : 20.04.2016 and all standards and guidelines listed below:

EN 12543-2, ASTM E1165

Bei einer mit dem Hersteller nicht abgestimmten Änderung des Produktes verliert diese Erklärung ihre Gültigkeit.

In any case of a change of the product not agreed by the manufacturer, this declaration will lose its validity.

Ort und Datum der Ausstellung
Langenfeld, 09.09.2020

Place and date of issue
Langenfeld, 2020-09-09

Geschäftsführer / Managing Director
Andre Storm

CE_1101021_2020_09

7 Contact Information and Impressum (§ 5 TMG)

KOWOTEST Gesellschaft für Prüfausrüstung mbH

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Dipl.-Ing. (FH) Fritz Hörauf
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