

NxS Tool User Manual

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The NxS Tool software was developed by CEA LIST within the scope of the NanoXSpot project (EMPIR/EURAMET 18NRM07 – project website: <https://www.ptb.de/empir2019/nanoxspot/home/>).

Main distribution website: <https://nanoxspot-project.cea.fr/>

Main contacts:

Marius Costin : Marius.Costin@cea.fr

Anthony Tournon : Anthony.Tournon@cea.fr

French Alternative Energies and Atomic Energy Commission

List Institute, Department of Imaging & Simulation for Non-Destructive Testing

CEA Saclay - DIGITEO Labs, Bldg 565

91191 Gif-sur-Yvette Cedex, FRANCE

www-list.cea.fr

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1. Introduction

This document describes the installation and the use of NxS Tool, a software used for evaluating the spot size and shape of X-ray micro- and nano- focus generators, based on the analysis of images acquired with special gauges. The implemented algorithms follow the methods as described in the proposed revisions of EN13543 standards (part 6 and 4), as well as an additional part (7) as drafted by the NanoXSpot consortium.

A set of sample images are provided with the software for training and verification. Reference datasets will be made available on the following webpage: [NanoXSpot Project - NxS Tool - Reference Images \(cea.fr\)](https://www.nanoxspot.com/NanoXSpot-Project-NxS-Tool-Reference-Images) and on a Zenodo repository.

2. Installation instructions

The software in its versions v2022.0x is released only for Windows OS. Future releases may include versions for Linux OS.

The software is released as an installation package. **We recommend to run it as a standard user, in which case the files will be extracted and installed in a folder inside the user area.** For Windows 10 the default folder is: C:\Users\[user name]\AppData\Local\Programs\NxS_Tool.

In case the installation is intended for several users, the setup should be run in Administrator mode, which will install all files in a common folder. When installed in the administration mode, the first run of the application may not succeed because of access rights limitations. Please close the Error/Warning popup and launch again the application as administrator.

The next figures displays the main installation steps for the case of a standard user. The installation language can be chosen between English, French and German.

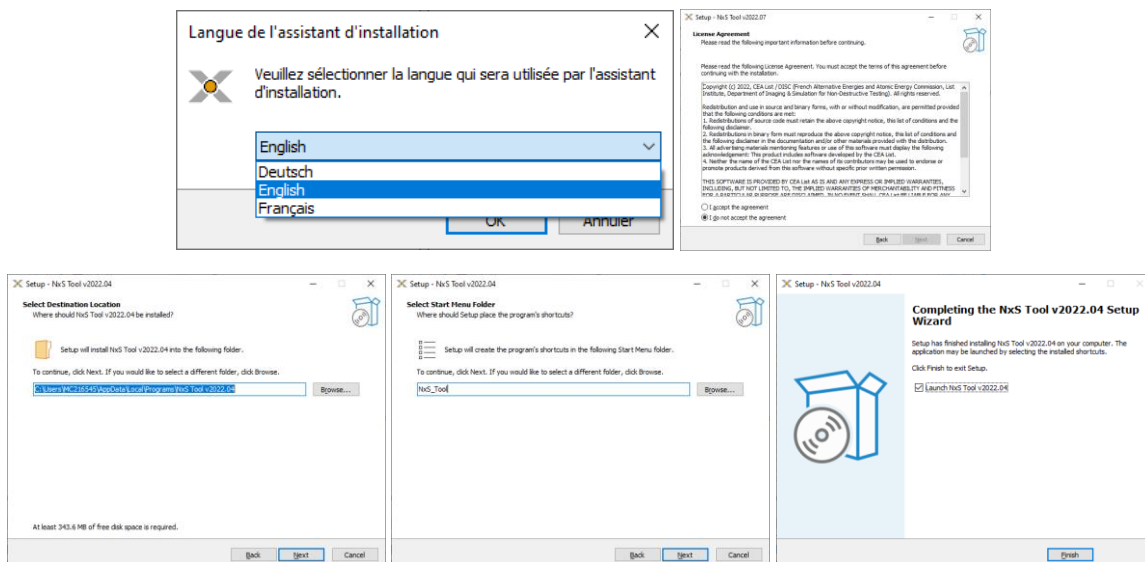


Figure 1: NxS Tool: main installation steps

After the installation is finished, the program may be launched with a shortcut from the desktop (if checked during the installation process).

3. General workflow

The general workflow is as follows:

- #1. Load one (or two) input images
- #2. Set the ROI(s) for evaluation
- #3. Run algorithm button → opens secondary window
- #4. Set detector, gauge, fit and export parameters and *Run* algorithm
- #5. The evaluation results will be displayed on the second window and will also be written on a text file on the hard drive.

The main window is displayed in the next figure with an image loaded for evaluation.

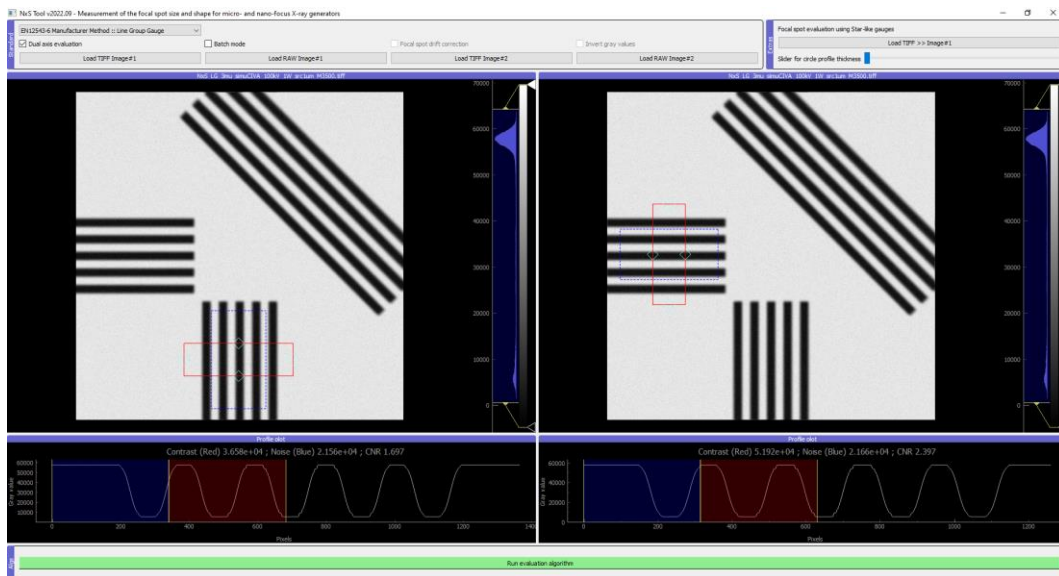


Figure 2: The main window of NxS Tool

Once the regions of interest are well set (step #2), the button “Run evaluation algorithm” (step #3) will open a second window. The contents of this secondary window depend on the evaluation method and its parameters.

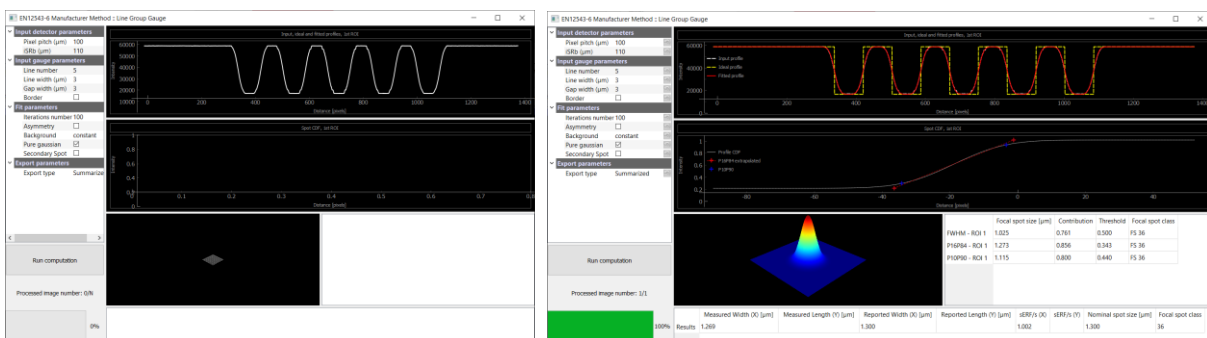


Figure 3: Secondary window for EN12543-6 Manufacturer Method, before and after computation

The results are presented on the second window, graphically and with estimated values. The table at the bottom of the window follows the recommendation of the proposed draft of the standard, with the measured dimensions (X/Y), the reported values, spot size values, the nominal spot size and the class, as defined by the standard.

3.1. Evaluation algorithms

3.1.1. EN12543-4 Line Profile Method

This method use a hole type pattern and is an evolution of the standards for the plate hole gauges. It is based on a dual profile evaluation at the transition generated by the hole wall. A perpendicular evaluation is proposed by default with two extracted profiles. This method could be extended in future for a sequence of angular orientations in order to evaluate the shape of the focal spot. Figure 4 and Figure 5 present respectively an example with this method.

Two perpendicular profile plots are used. By default, these are positioned centered with respect to the hole and the width can be adjusted with the points at the center of the two ROIs.

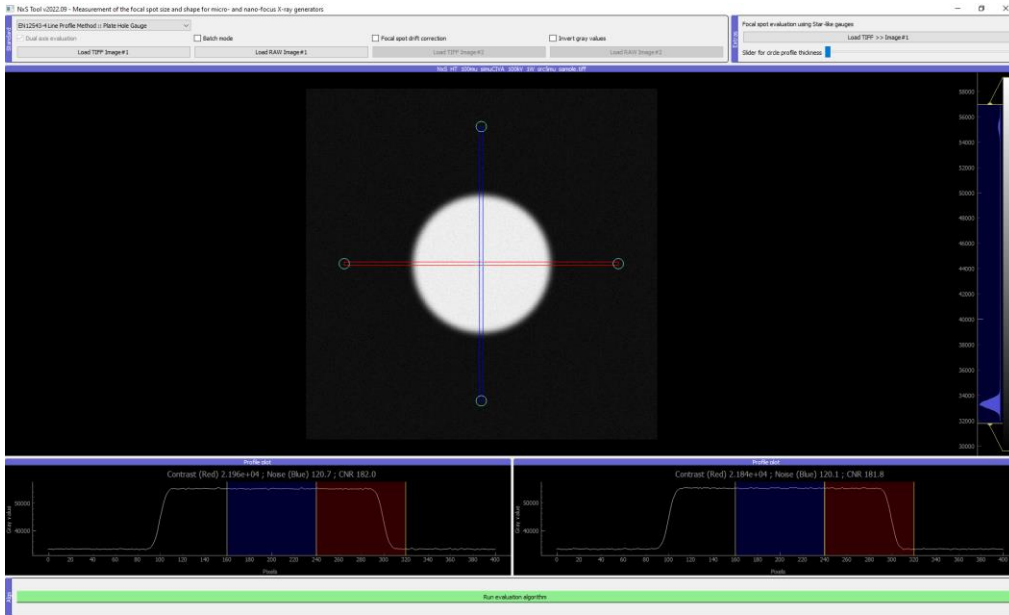


Figure 4: EN12543-4 Line Profile Method, selection of ROIs

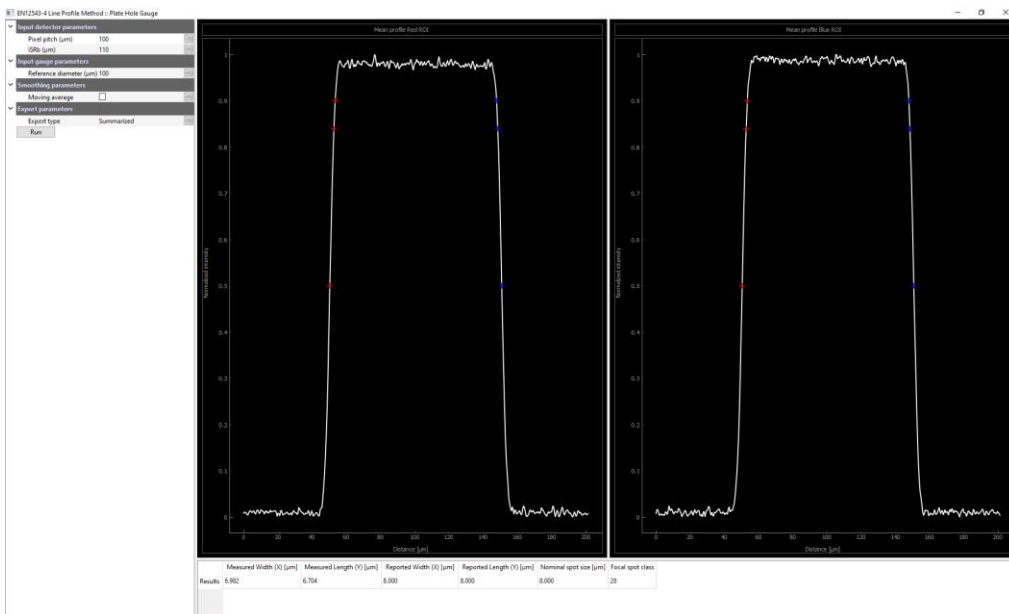


Figure 5: EN12543-4 Line Profile Method, results window

3.1.2. EN12543-6 Manufacturer Method

The algorithm follows the evaluation method proposed by the standard EN12543-6, which is a line group fit. The algorithm should be used with two images in order to extract the values on perpendicular directions. If the acquired image contains both necessary patterns, the same image can be loaded for the bi-directional evaluation. Such an example is presented in Figure 6.

A rectangular ROI is positioned by default at the center of the image. Its position, orientation and width must be adjusted to the image such that the profile plot shows the modulation correctly. It is recommended to use a profile support (length of ROI) about twice the width of the line group and center the modulation on it.

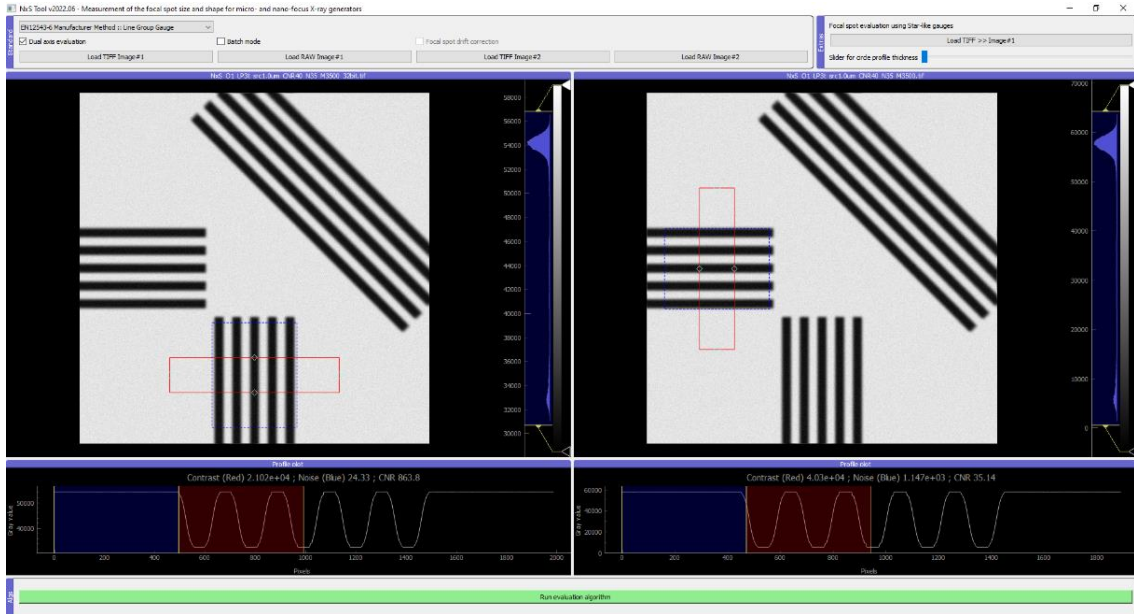


Figure 6: EN12543-6 Manufacturer Method, selection of ROIs

In this case, the results will also be presented as a dual view, one per axis. An example is provided in Figure 7.

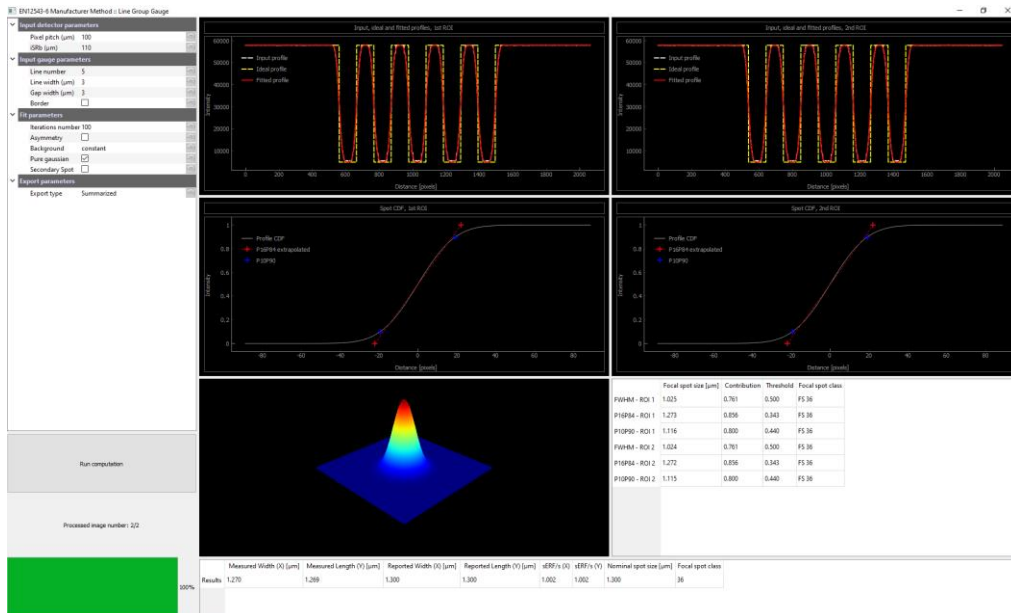


Figure 7: EN12543-6 Manufacturer Method, results window

3.1.3. EN12543-6 User Method

The algorithm follows the evaluation method proposed by the standard EN12543-6 – User method. This method is based on the analysis of the modulation depth of line group profiles, extracted from two profile plots with different line pair widths. Figure 8 presents the main window for this method and Figure 9 presents an example of the results window.

A rectangular ROI is positioned by default at the center of the image. Its position, orientation and width must be adjusted to the image such that the profile plot shows the modulation correctly. It is recommended to use a profile support (length of ROI) about twice the width of the line group and center the modulation on it.

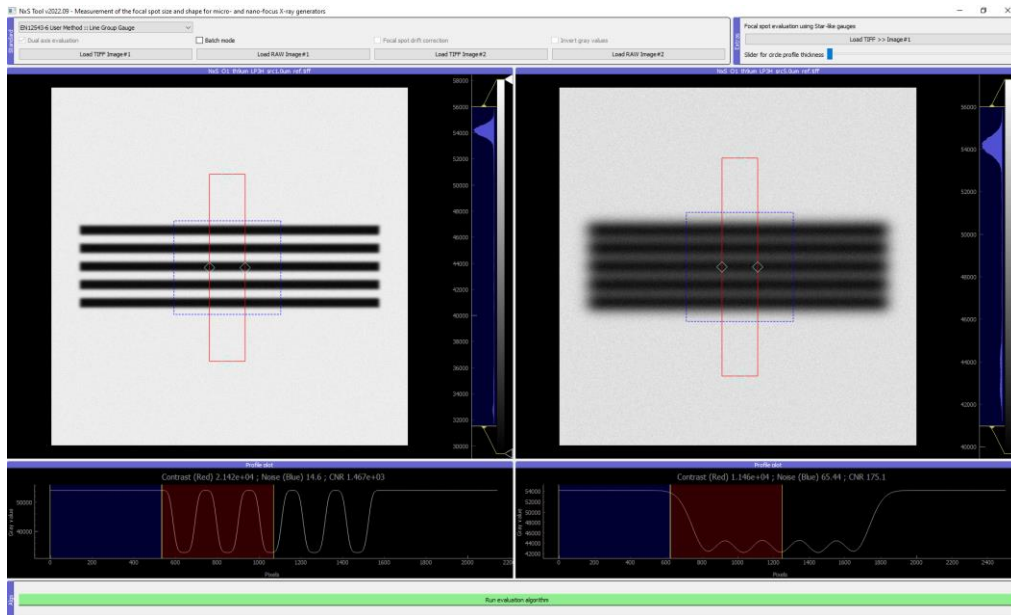


Figure 8: EN12543-6 User Method, selection of ROIs

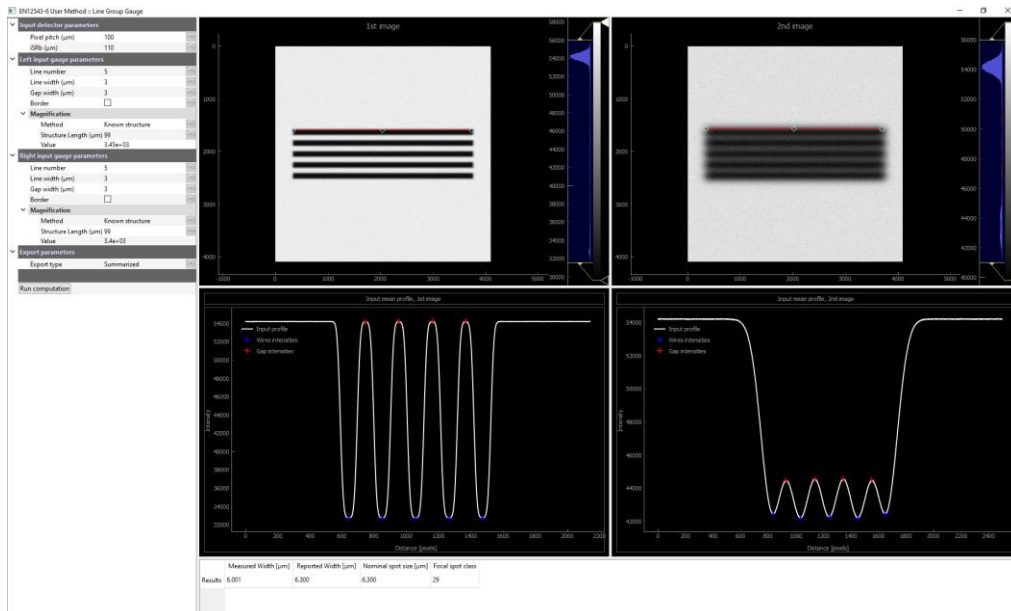


Figure 9: EN12543-6 User Method, results window

3.1.4. EN12543-7 Manufacturer Method

The algorithm follows the evaluation method proposed by the standard EN12543-7(-4), which is a focal spot reconstruction method with a back-projection technique. The resulting shape is fitted with a 2D Gaussian-shape function. The algorithm is similar to the one used in the “X-ray focal spot shape evaluation by means of filtered back projection of circular edge profiles” provided by [METAS](#), with some differences on the selection of the input ROI used in the construction of the sinogram-like intermediate image. Figure 10 and Figure 11 present respectively the main window and the results window for this method.

A rectangular ROI is positioned by default to cover entirely the image. Its size and position can be adjusted if needed. It is recommended to use size of the ROI about twice the diameter of the hole.

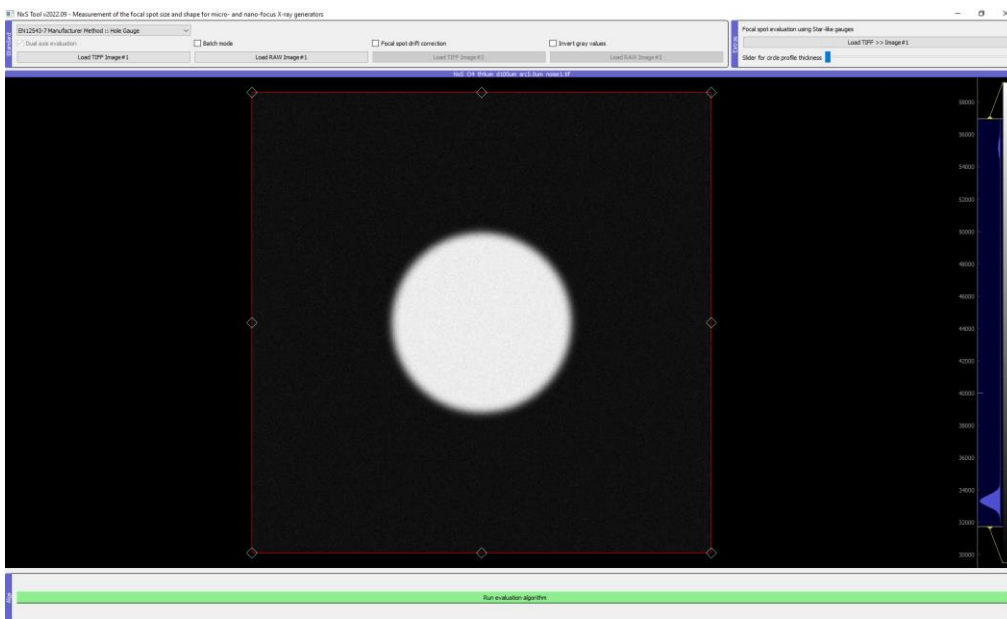


Figure 10: EN12543-7 Manufacturer Method, main window

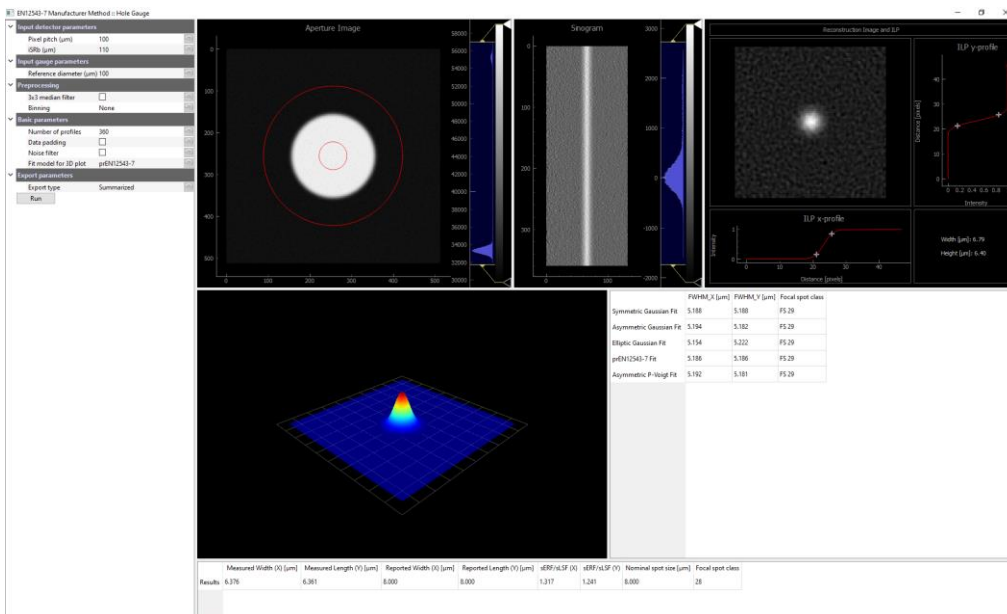


Figure 11: EN12543-7 Manufacturer Method, results window

A focal spot drift correction is implemented for this method, for the cases where the noise levels are low and several images must be used. It functions as a batch mode by using all the available images in

a selected folder which are pre-processed for finding the center of the hole before generating an average image. This average image is then used by the backprojeciton algorithm.

3.1.5. EN12543-7 User Method

Similarly to EN12543-4 Line Profile Method, this method use a hole type pattern and it is based on a dual profile evaluation at the transition generated by the hole wall. A perpendicular evaluation is proposed by default with two extracted profiles. The main difference with respect to EN12543-4 is a factor which is applied for the calculation of the focal spot size, 1.40 instead of 1.47. Figure 4 and Figure 5 present respectively an example with this method.

Two perpendicular profile plots are used. By default these are positioned centered with respect to the hole and the width can be adjusted with the points at the center of the two ROIs.

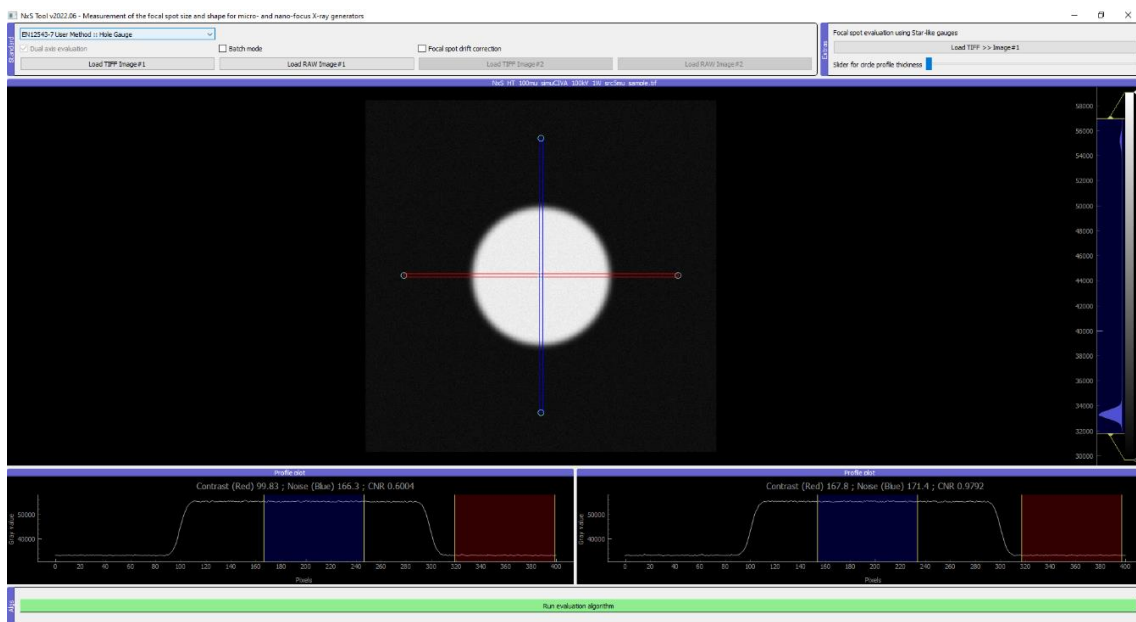


Figure 12: EN12543-7 User Method, main window

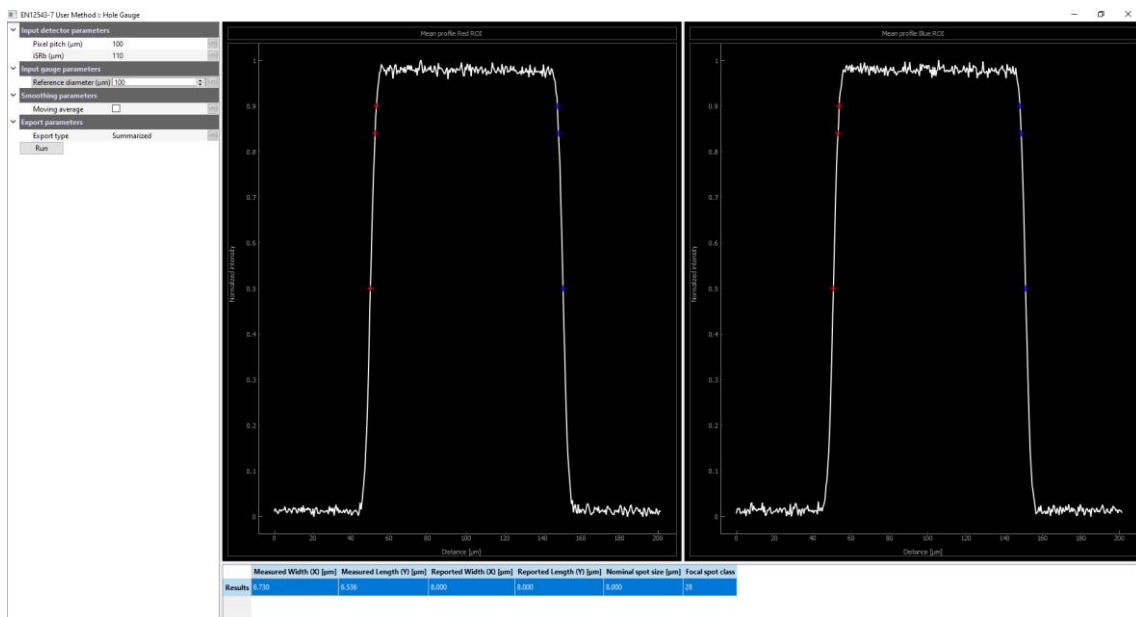


Figure 13: EN12543-7 User Method, results window

3.1.6. Focal spot evaluation using Star-like gauges

This method is derived from the focal spot reconstruction method and uses star-like patterns. It needs as input a radial pattern and a reference size for a diameter which serves for the correct estimation of the magnification and sampling. A profile is extracted on a circular support and then processed in a similar manner to the focal spot reconstruction. An example of the main window is displayed in Figure 14. The functionality is implemented and it was tested on few images, but since it will probably will not be included in the proposed standards, a lower priority was assigned for development and validation. The NxS Tool version 2022.07 has disabled the run of this method.

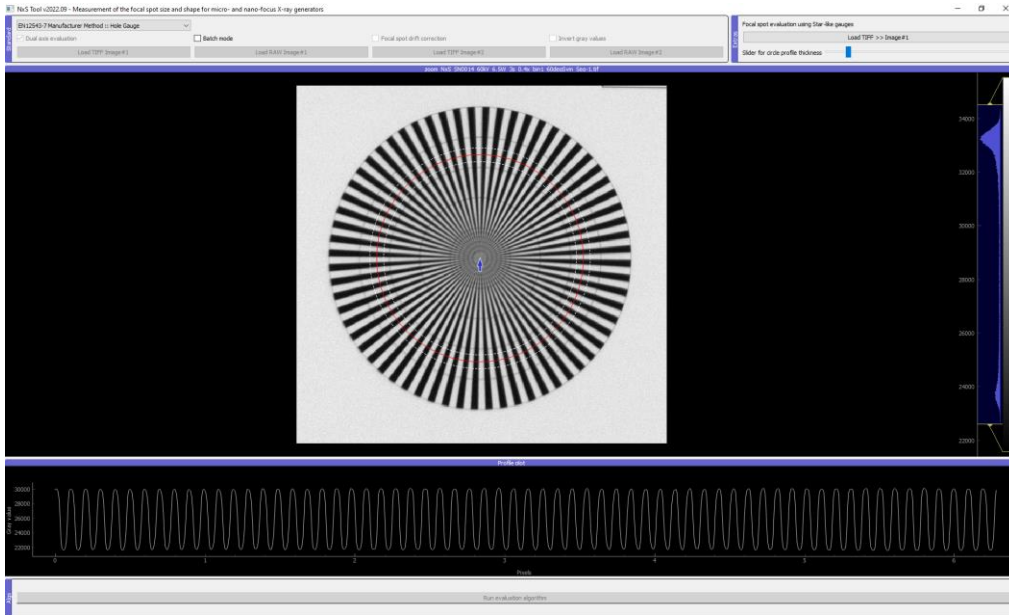


Figure 14: Focal spot evaluation using Star-like gauges, main window

4. Other features

4.1. Batch mode

A batch mode can be used for processing a set of images, by checking the option in the first panel of the main window. The user should prepare the images to analyze in separate folders, per type of gauge and characteristics, since all the images in one folder are processed in an identical manner. When the button “Batch mode” is checked, the loading step will open a new window to specify the ROI for all images in the folder (see Figure 15). The user can choose a specific orientation and position of the ROI for each and every image.

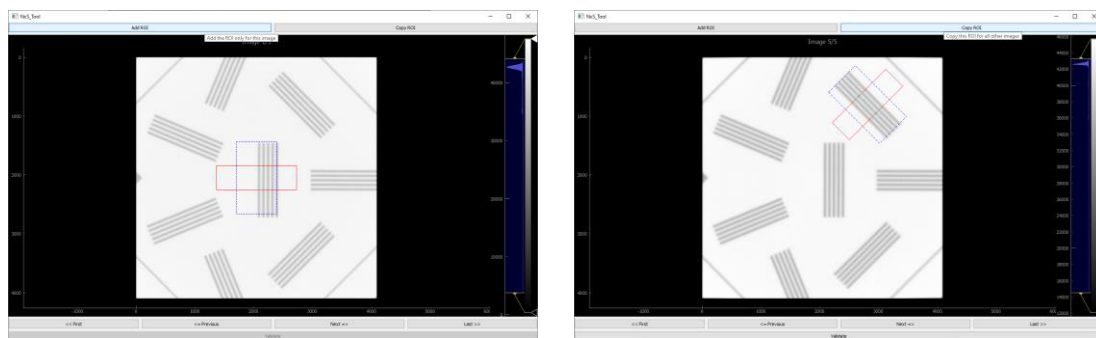


Figure 15: ROI definition window

After defining the ROIs, the usage follows the normal workflow with the definition of input, evaluation and output parameters. The algorithm is applied on all the images in the list and the results are listed into a text file (.csv – with tab separator) next to the input files.

4.2. Focal spot drift correction – for hole type evaluation

A focal spot drift correction method is implemented for cases of images with very high noise levels. In this scenario, the user can acquire a sequence of images with the same settings. All images should be copied to a separate folder before analysis. When enabling this option in the first panel of the main window, a pre-processing step is executed before the run of the evaluation algorithm. This step consists of identifying the centers of the hole patterns and then re-centers all the set. Once centered, an average image is computed in order to reduce the noise. This pre-processed image is then used for the focal spot evaluation.

5. Sample images

The folder `_SampleImages` found at the root of the installation folder contains few examples, generated with the help of simulation software (CIVA RT/CT and aRTist).

The generated images follow the naming convention proposed by the NanoXSpot consortium. More precisely, these conventions are:

- Folders will be ordered hierarchically and will be clearly named, e.g. indicating partner.
- Image files created during the validation tests will be uniquely named by including the following information:
 - gauge identification (e.g. NxS, RC-02B, RC-04, RC-05, ...)
 - structure type (LG = Line Group, HT = Hole Type)
 - structure identification
 - line width and orientation relative to gauge for line groups
 - row/column notation for holes as given on the NanoXSpot gauge
 - X-ray source name
 - source operating mode identification (NA if not applicable)
 - acceleration voltage, e.g. 100kV
 - target power, e.g. 1W
 - image type according to distributed instructions (identifying intended parameter variation)

An example of such file name is:

`NxS_HT_10mu_simuCIVA_100kV_1W_srcOp8mu_M2000_CNR40.tiff`

6. Frequently asked questions

- *What is the default installation folder?*
A: `C:\Users\[user name]\AppData\Local\Programs\Spot Size Evaluate`
In the case of installation as administrator, the folder is placed in the `/Program Files/` folder. Please note that starting with Windows 10 you need administration rights to run from that folder
- *How to set perfectly horizontal or vertical ROIs?*
A: Keep the Ctrl key pressed when setting the ROI with the mouse, the “snap” function is set to intervals of 22.5°.