SolarLS.LAB Software

User's Manual

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Document Version

Document Number	Version
501m-e-00001-201709	First release

I. Introduction

Dear Customer! Congratulations on purchasing Solar LS production! Please, read this User's Manual thoroughly before operating with **SolarLS.LAB**.

Document Purpose

This document contains all necessary information about **SolarLS.LAB** software, installation and configuration steps, User's interface description and routine operation.

General Information

SolarLS.LAB is a modern software for automated control of monochromators & spectrographs produced by Solar LS and for operation with spectroscopic data.

SolarLS.LAB allows multiple device and detector connection to PC and quick inter-switching. High level of automation enables fast spectra recording and data extraction. Spectra can be saved or exported to CSV, BMP or PNG files for further processing.

System Requirements

SolarLS.LAB is supported by the following operational systems:

- Windows XP Service Pack 3 (32/64bit)
- Windows 7 (32/64 bit)
- Windows 8 (32/64bit)
- Windows 10(32/64bit)

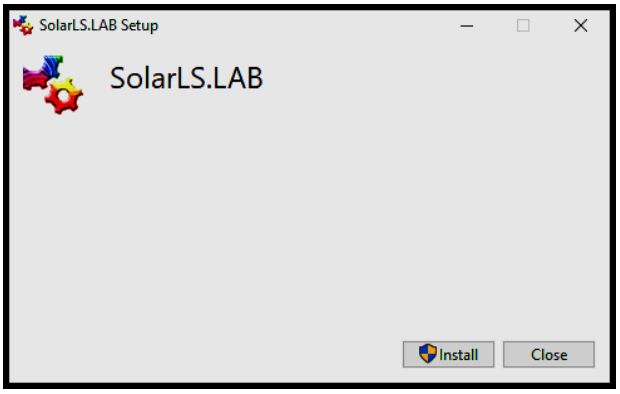
SolarLS.LAB is not compatible with Windows 7 Starter edition!

Make sure that your video controller is not driven by third party drivers!

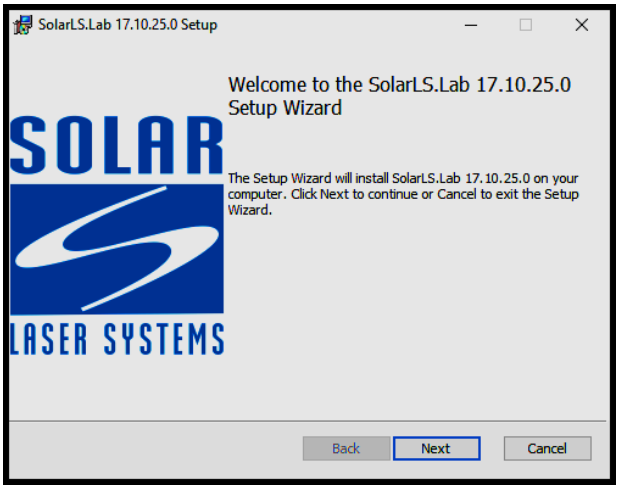
II. Installation

Do not connect your spectral instruments and detectors to PC until the software installation is complete.

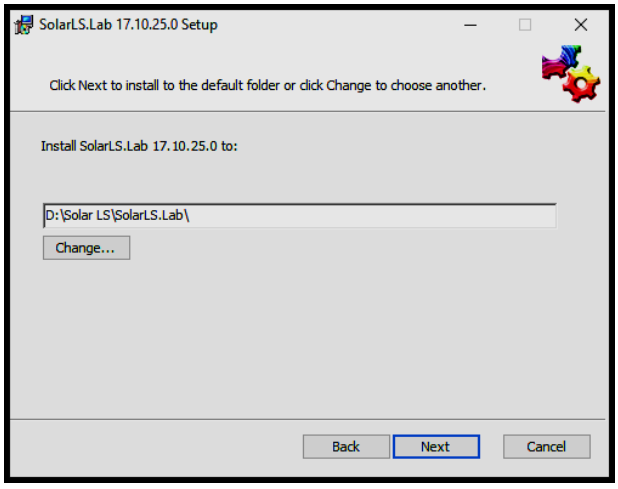
Connect the supplied USB-flash drive to the corresponding socket of your PC. Open the folder **«Setup SolarLS.LAB»** and launch the executive file **«SolarLS.LAB.setup.exe»**. The following window will appear:



Click the **«Install»** button. Wait until the required libraries are installed. The following window will appear:



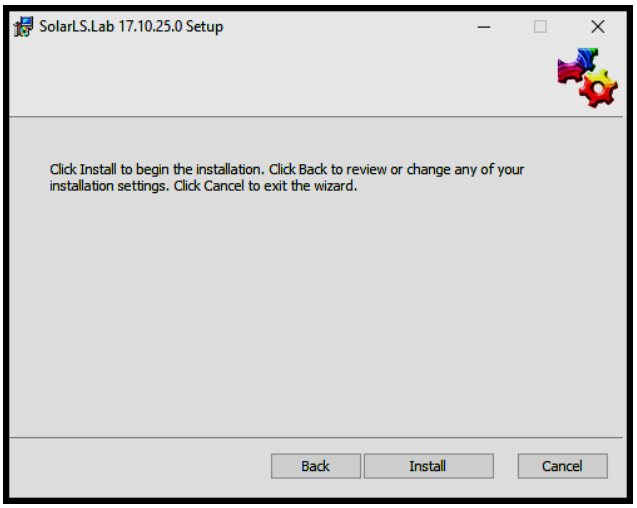
Click the **«Next»** button**.** The next window will appear on your display:



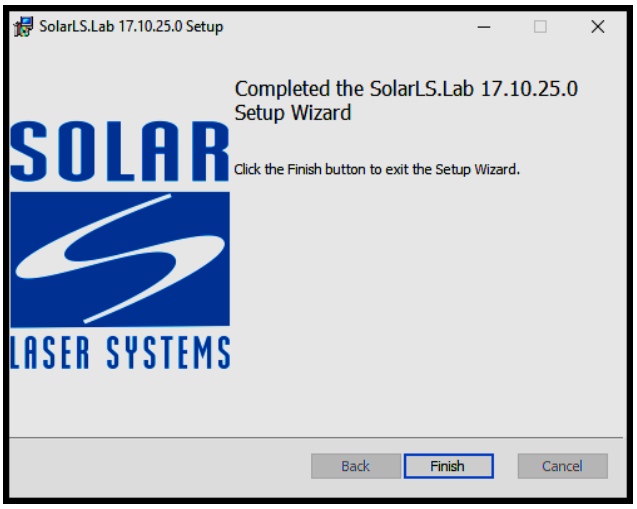
Here you can choose the destination folder for software installation.

Do not use «C:\Program Files\...» folder as destination one. Use only Latin characters while specifying the destination folder.

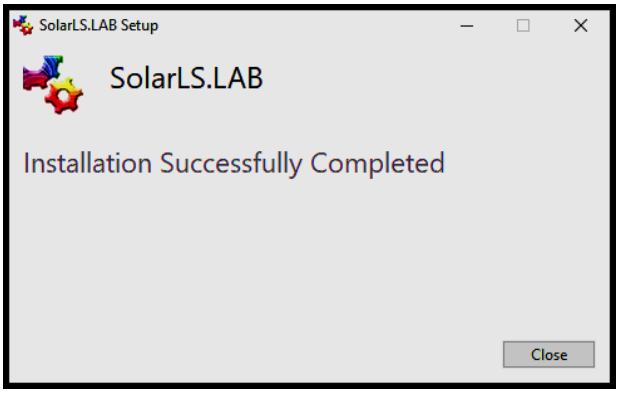
The software will be installed to **«C:\SolarLS\SolarLS.LAB»** by default. To change the destination folder click the **«Change…»** button. Then click the **«Next»** button**.** To start the installation process, click the **«Install»** button in the newly opened window**.**



Once the software is installed, the following window will appear:



Click the **«Finish»** button**.** In the last window, click **«Close»**:



You can find a shortcut **«SolarLS.LAB.exe»** on your desktop for a quick launch.

Once **SolarLS.LAB** software installation is complete, connect your spectral instrument(s) and detectors to your PC via the supplied USB-cables. Drivers for your devices will be installed automatically after the connection.

Launch the **SolarLS.LAB** software.

If the following window will appear, it means, that no device is connected to your PC. Check the connection, power-on the instrument(s) and launch the software once again.

During the first launch the **«Select Device(s)»** window will appear**:**

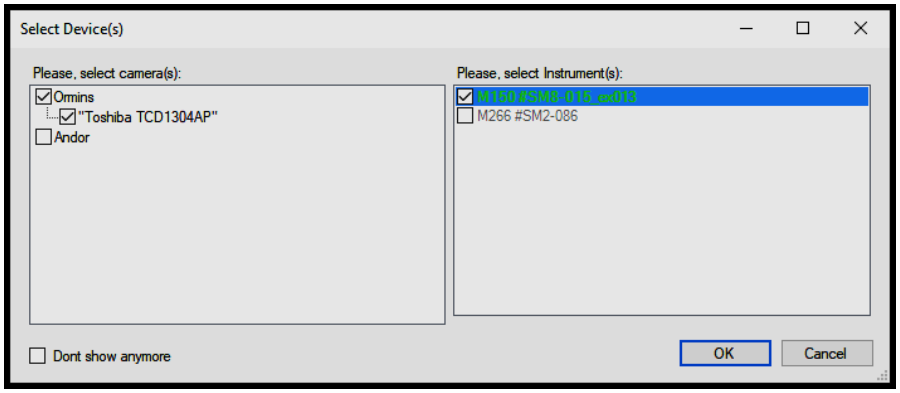


Fig. 1 «Select Device(s)» window

The list of available connected cameras is displayed within the left box of the configuration window, and the right box (*intended for monochromators*) contains the list of available device configuration files containing the serial number of specific device. Place checkmarks of desired configuration and click the **«OK»** button. Software **SolarLS.LAB** is ready for operation. If the checkbox **«Don't show anymore»** is checked, the **«Select Device(s)»** will not appear after the next launch of the software.

III. Software Interface

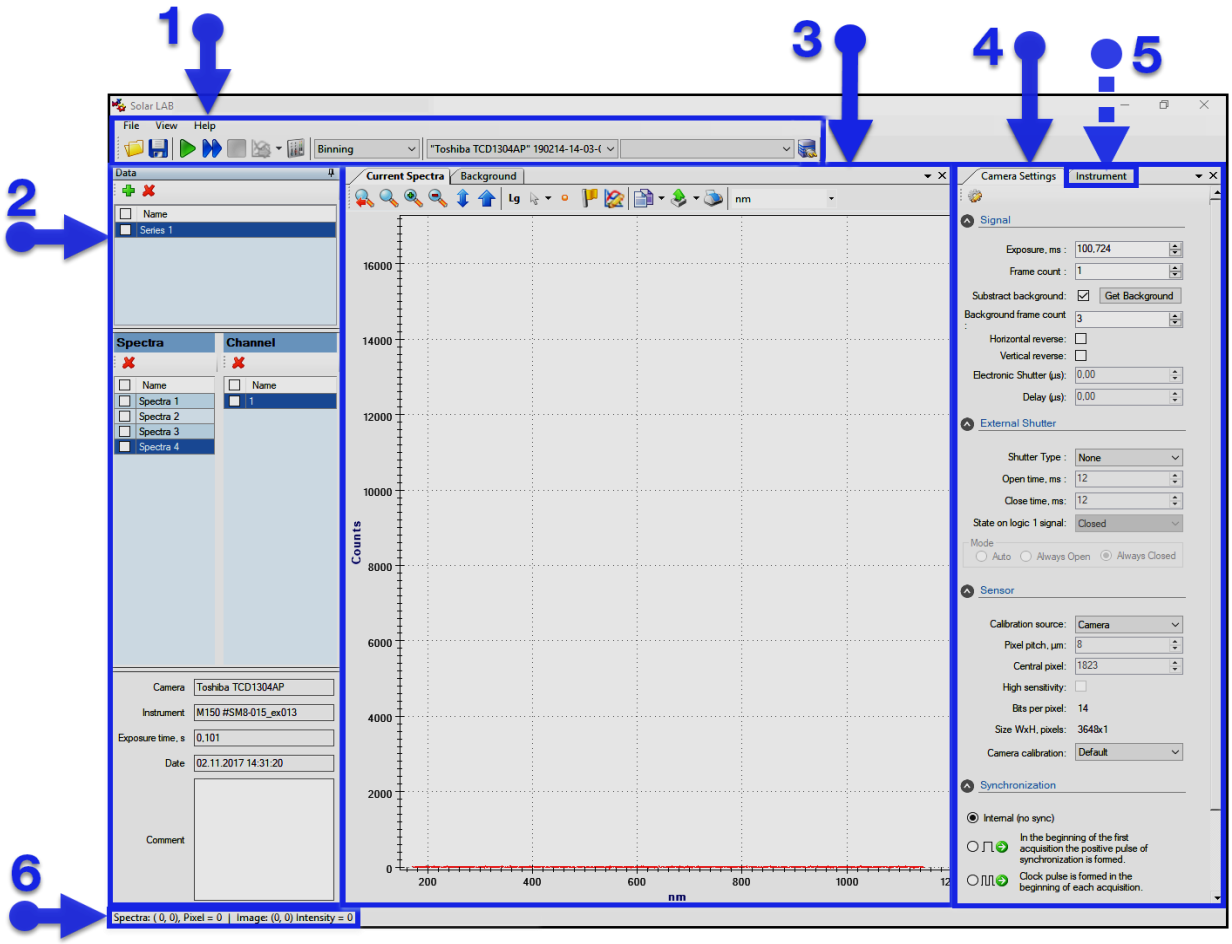


Fig. 2 SolarLS.LAB interface

SolarLS.LAB working interface consists of several control windows, configuration windows and status bars. In Figure 2 you can see a standard SolarLS.LAB interface, which includes the following:

1. *Main panel.*
2. *Data panel* – recorded spectra are stored and selected within this panel.
3. *Current Spectra panel* – recorded spectra are displayed within this panel.
4. *Camera Settings Panel* – camera and registration parameters are configured within this panel
5. *Panel Instrument* (click the hiding tab to view) – monochromator units and mechanisms are controlled within this panel.
6. *Status bar*

Panels can be arranged and resized. Interface user's adjustment is described in Appendix A of the present User's Manual.

Main Panel

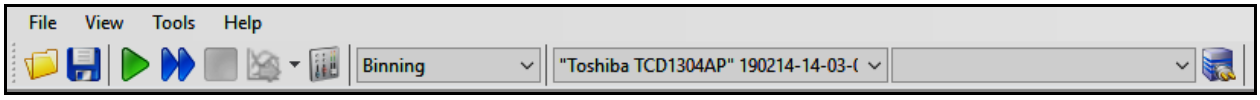
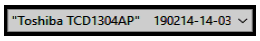
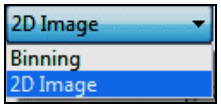


Fig. 3 SolarLS.LAB Main panel

Main panel contains the following buttons and menus:

 ***Open***	Open the previously saved working space of .labws format
 ***Save***	Save the current working space in .labws format file
 ***Register***	Start single spectrum registration
 ***Continuous***	Start continuous spectra registration with parameters specified in *Camera Settings* panel
 ***Stop***	Stop the continuous spectra registration. The last spectrum will be stored to *Data panel*
 ***Scan***	Start panoramic spectra registration
 ***Filtering***	Open *Filter* window to apply filter to the active spectrum
	Select the active connected camera to operate with
	Select the active monochromator to operate with
 ***Device selection***	Open the *Select Devices* window
	Select the operation mode: *Binning* or *2d image*
File tab	*Create new* – create a new working space in .labws format *Open* – Open the previously saved working space in .labws format *Save* – Save the current working space in .labws format file *Save as* – Save the current working space in a new .labws format file *Exit* – close SolarLS.LAB software
View tab	*Data* – show Data panel *Colorimetry* – open tab with colorimetry measurements results *Current Spectra* – show Current Spectra panel *Background* – show Background panel with the registered dark signal in the Binning Mode *2D image* – show *2D image* tab (intended for array detectors) *2D image Background* – show 2D Image Background panel *Camera*– show Camera Setting panel *Instrument*– show Instrument panel for monochromator control
Tools tab	*Color Calculator* – open the calculator tool for the colorimetry coefficients *Filtering* – open the tool for spectra filtering *Atomic Lines* – open the atomic lines database *Video Camera* – open the capturing video window (for specific devices) *Options* – open visual interface preferences
Help tab	*About* – information about the software version

Instrument Panel

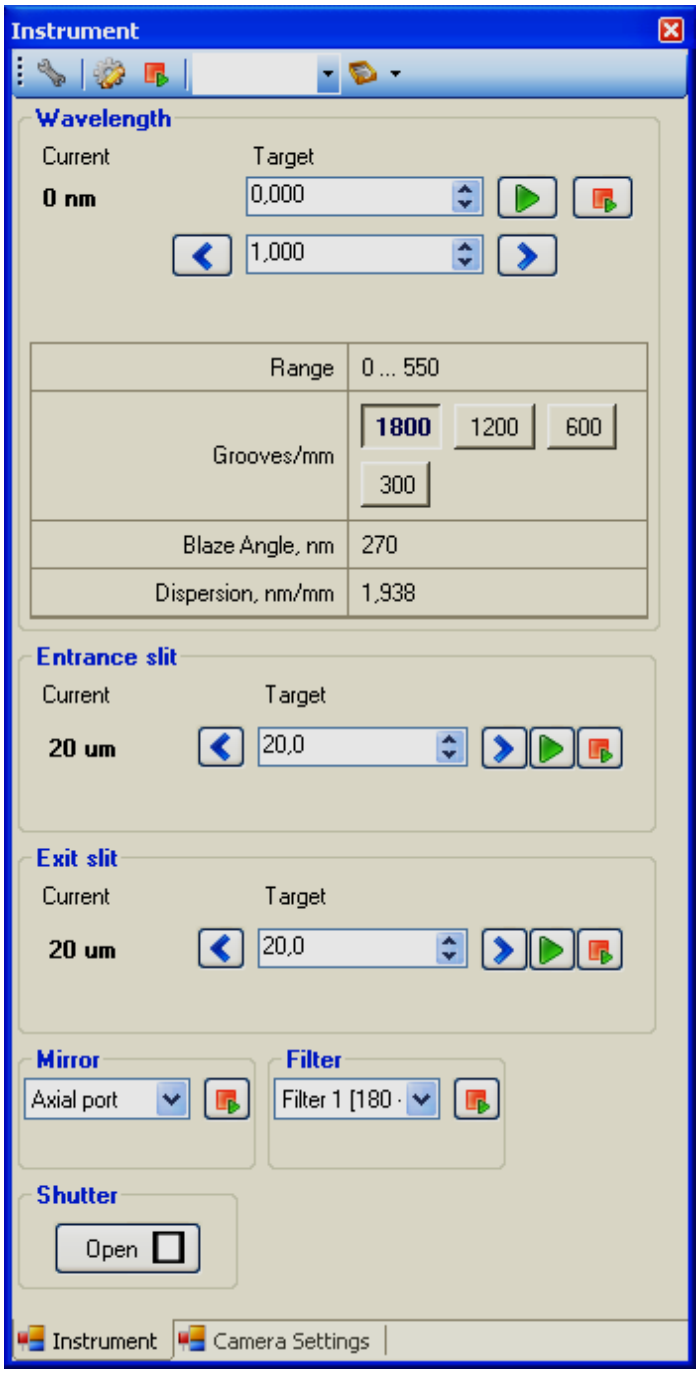


Fig. 4 Instrument Panel Complete View

Panel ***Instrument*** (Fig. 4) contains a button for wavelength correction (), Instrument Configuration button (), Reset+Set All button () and sub-panels: *Wavelength, Entrance slit, Exit Slit, Mirror, Filter, Shutter.*

The presence of control sub-panels may vary among instruments.

Reset + Set All  ***button is intended for simultaneous transfer of all mechanisms to Reset position and subsequent reconstruction to previously set parameters.***

«Wavelength» Panel

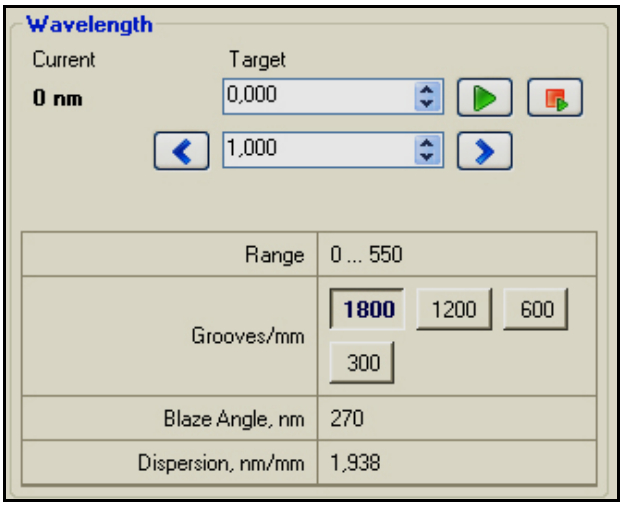


Fig. 5 Wavelength panel

Wavelength panel is intended for setting the wavelength of monochromator output light and automated change of diffraction gratings.

Target	Entry field for a new wavelength value the monochromator will be set
Current	This field displays the current wavelength the monochromator has been set
	Click this button to set the monochromator to the wavelength with value from a ***Target*** entry field
	Click this button to set the monochromator to the wavelength with value from a ***Target*** entry field with preliminary moving the grating turret to ***Reset*** position for better accuracy. This step takes more time as compared to the previous one but allows deleting stored errors and fine-tuning of the instrument to the required wavelength
	These buttons are used to decrease and increase the current wavelength by one step, respectively. The step value is set in the entry field between these buttons. By holding down one of these buttons, a cyclic step-by-step change of the current wavelength is provided.
Range	Operational spectral range of the active diffraction grating
Grooves/mm	Amount of grooves per 1 mm. These buttons are used to select the active diffraction grating by clicking the button with correspondent value. Button  is intended to set the grating with a largest amount of Grooves/mm as active with preliminary moving the grating turret to *Reset* position for better accuracy
Blaze Angle, nm	Blaze wavelength of the active diffraction grating
Dispersion, nm/mm	Reciprocal linear dispersion at the current wavelength of the active diffraction grating

«Entrance slit» and «Exit slit» Panels

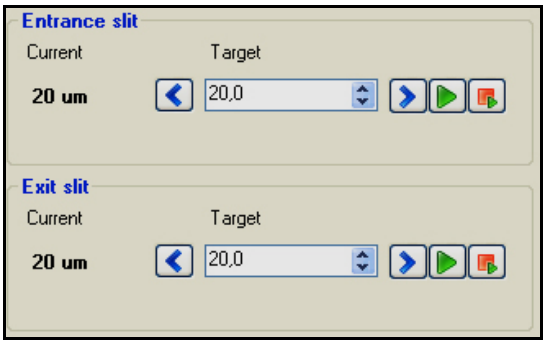


Fig. 6 Panels Entrance slit and Exit slit

Since these panels contain completely the same control tools, the following description applies both to ***Entrance Slit*** and ***Exit Slit*** panels.

Target	Entry field for a new slit width value
Current	Current slit width
	Click this button to set the new slit width with a value from **Target** entry field
	Click this button to set the new slit width with a value from **Target** entry field, with preliminary setting the slit width to a zero value
	These buttons are used to decrease and increase the slit width by one step, respectively. By holding down one of these buttons, a cyclic step-by-step change of the slit opening width is provided.

«Mirror» Panel

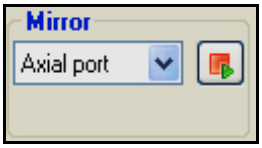


Fig. 7 Mirror Panel

The active input or output port is selected via the popped-down list in panel **Mirror**:

Axial Port – select axial output port as active one

Lateral Port – select lateral output port as active one

«Filter» Panel

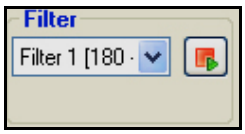


Fig. 8 Entrance Filter Panel

Popped-down list is used for changing the active filter. Each filter designation contains the wavelength range of filter operation.

«Shutter» Panel

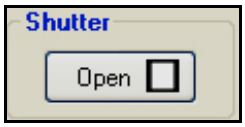
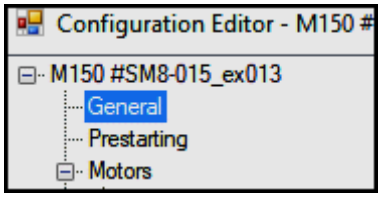


Fig. 9 Shutter Panel

Checkbox in position **Open** is used to open the integrated shutter. Checkbox in **Close** position is used to close the shutter.

Configuration Editor. Auto Control



Click the Instrument Configuration button () to open configuration editor. Click on the **General Tab.** You will see on the display the following Auto Control features:

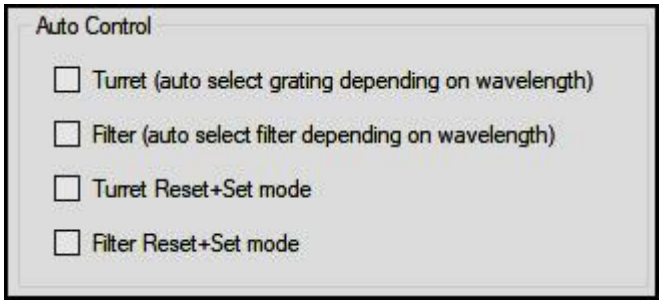


Fig. 10 General configuration tab

Turret	If checked, grating will be selected automatically dependent on wavelength
Filter	If checked, filter will be selected automatically dependent on wavelength
Turret Reset+Set Mode	If checked, will force Reset + Set mode () instead of Set mode () for turret of gratings
Filter Reset+Set Mode	If checked, will force Reset + Set mode instead of Set mode for filter wheel

Configuration Editor. Prestarting

Click the Instrument Configuration button ( ) to open configuration editor. Click on the **Prestarting tab.** You will see on the display the following Prestarting features:

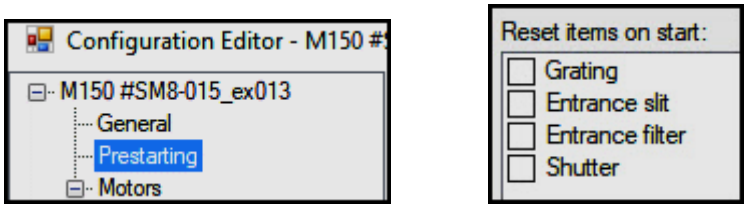


Fig. 11 Prestarting settings

Check the required units that will be forced to Reset state during the software launch.

Other tabs are intended only for manufacturer or service engineer.

Presets

The preset values of mechanisms, units and instrument window tabs may be selected, created, saved or loaded at the top of ***Instrument panel.*** Press on the arrow near the button to expand the presets list.

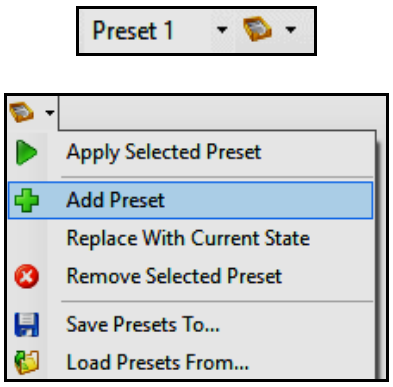


Fig. 12 Presets

Click ***Add Preset*** and input the name to save the current values in ***Instrument Panel*** as a new preset.

To apply the existent preset expand the list of presets left to the button and click on its name or click ***Apply Selected Preset***. You can change the values of the active preset with the current values by clicking **Replace with Current State**.

Remove Selected Preset – delete the selected preset.

Save Presets To… - save the presets list to file.

Load Presets From… - load preset form file.

Camera Settings Panel

On the top of the **«Camera Settings»** panel is located the  button. Once it is clicked, the additional settings will be opened.

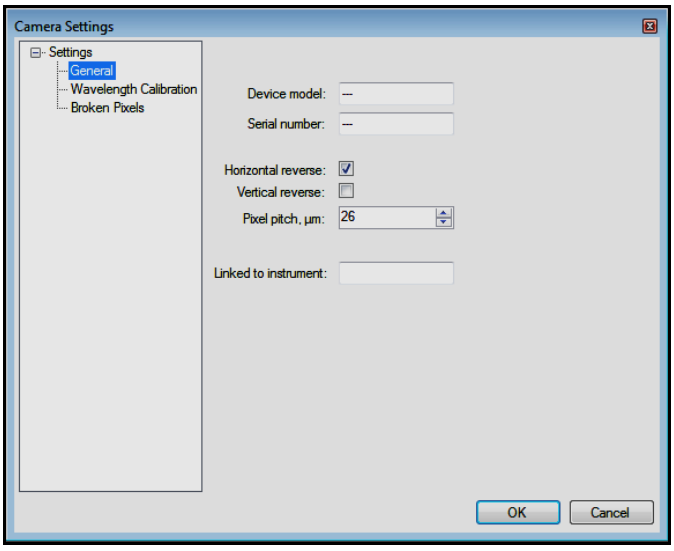


Fig. 13 General camera settings

Device model	This field holds the name of your device
Serial number	This field holds the serial number of your device
Horizontal reverse	If checked, the horizontal axis will be reversed. The spectrum will be displayed mirror symmetric relative to the vertical axis and the direction of axis digitization will be reversed
Vertical reverse	The spectrum will be displayed mirror symmetric relative to the horizontal axis. This feature may useful for absorption spectra analysis.
Pixel pitch, µm	The distance between two adjacent pixels of the detector. It is set in micrometers according to specification of the detector.
Linked to instrument	This field holds the serial number of the monochromator that contains the selected camera

On the left, click the *Broken Pixels* to open the following window:

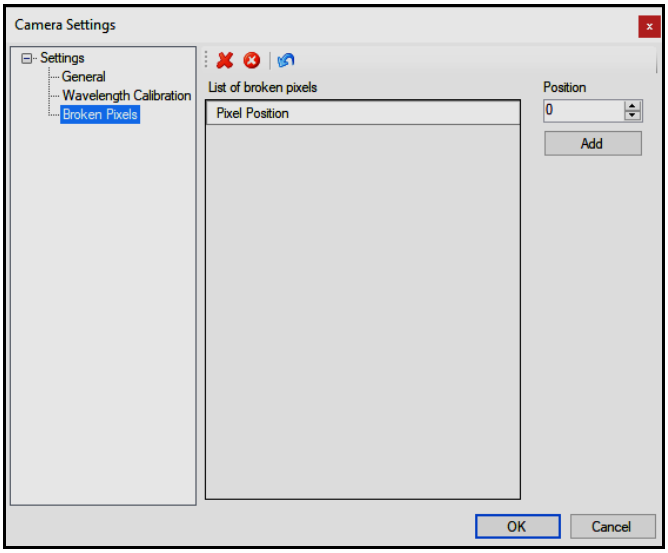


Fig. 14 Broken pixels correction window

If any pixel becomes “broken” (i.e. produces a lot of readout noise or becomes oversaturated) for any cause, it can be corrected via this tab. Add a ***position*** (number) of a broken pixel and click **«Add»**. Henceforward the intensity for this pixel in the recorded will be neglected – it will be calculated as a mean relative intensity of the adjacent pixels.

The *Wavelength Calibration* tab is described on page 28.

Signal panel

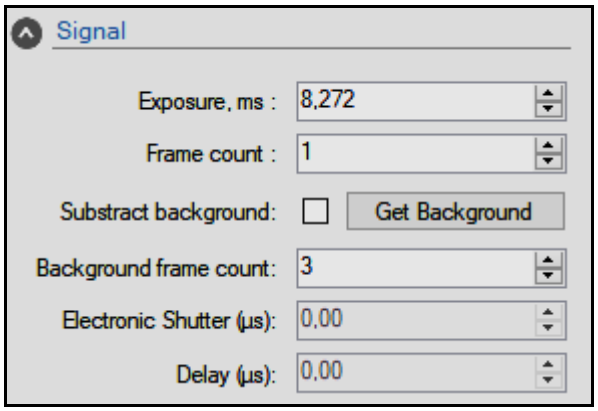


Fig. 15 Signal tab

Exposure, ms	Exposure time (charge accumulation time). It is set in milliseconds and may be divisible by minimum charge accumulation time only (depends on the type of detector)
Frame count	Each time a spectrum is registered the number of frames is also registered, then these frames are averaged and background signal is subtracted (if required). The averaged spectrum will be displayed. This feature is intended to smooth the resulting spectrum and to increase signal-to-noise ratio. The maximum number of frame counts depends on the RAM capacity of your PC
Subtract background	If checked, forces automated background recording and further subtracting from the averaged recorded spectrum
Get Background	Record a dark signal for further automated background subtraction (intended for operations without shutter). Click View-Background or View-2D Image Background to open the tab that contains the recorded background
Background frame count	Number of frame counts for background recording
Electronic shutter (µs)	Available only for a min. exposure time, sets the time for electronic shutter active state.(for cameras with electronic shutter)
Delay (µs)	Sets the delay time for triggering of electronic shutter. (for cameras with electronic shutter)

External Shutter panel

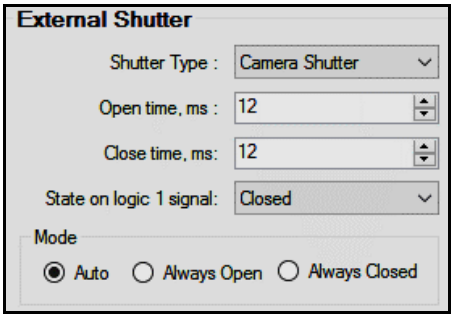


Fig. 16 External shutter tab

Shutter Type	Select the operating type of the used shutter: *None* – no shutter is present.. *Manual* – the manual shutter switch is supposed for measurements *Internal Shutter* – operation with the internal camera shutter with the desired parameters Open time and Close time *Instrument Shutter* – operation with the shutter integrated in your monochromator
Open time, ms	Shutter opening time in milliseconds
Close time, ms	Shutter closing time in milliseconds
State on logic 1 signal	Shutter state on logic-1 level
Mode	Select shutter operational mode: *Auto* – automated operational mode with pre-set values *Always Open* – shutter is always in opened state *Always Closed* – shutter is always in closed state

Sensor panel

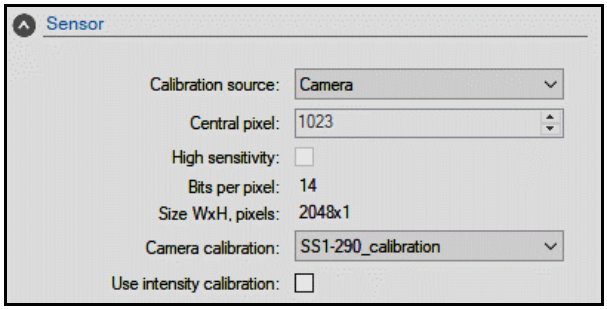


Fig. 17 Sensor panel

Calibration source	Select a device as a calibration source: *Instrument* – for monochromators *Camera* – for spectrometers or detectors installed in monochromators
Central pixel	The index of the central pixel of the detector. It is set according to the specification of the detector.
High sensitivity	Switch on/off the high sensitivity mode. Available only for detectors with this feature.
Bits per pixel	ADC resolution in bits per pixel. This value depends on the type of detector.
Sensor size, WxH	Detector's active sensor area size in pixels
Camera calibration	Select the calibration from list and set as active
Use intensity calibration	If your device features the factory intensity calibration, check this box to recalculate the ADC counts to the absolute spectral irradiance (W/nm*m^2)

Synchronization Panel

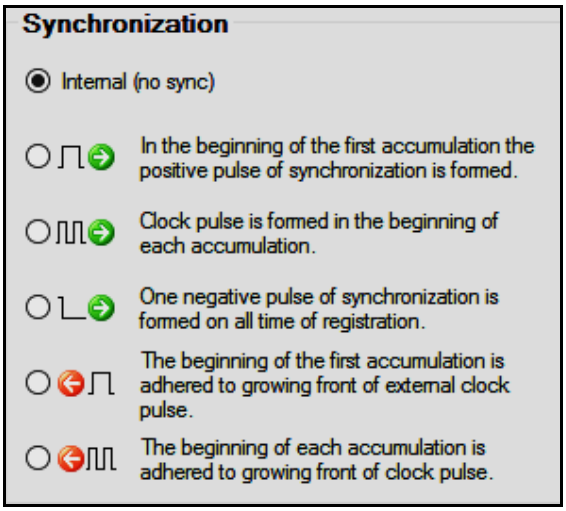


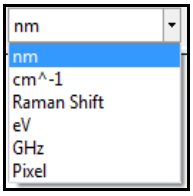
Fig. 18 Synchronization panel

Internal (no sync)	Synchronization is absent. Spectra are recorded at regular intervals in accordance with the pre-set values parameters: Exposure time, Mode
	Readout is performed at regular intervals in accordance with the pre-set values Exposure time, Mode; a positive sync pulse is formed only before first readout
	Readout is performed at regular intervals in accordance with the pre-set values Exposure time, Mode; pulses with the following parameters appear at the device synchronization output preceding every readout step (load resistance 1000 Ω)
	Registration is performed in accordance with pre-set values Exposure time, Mode. A negative sync pulse is formed only before first readout.
	Registration is performed in accordance with pre-set values Exposure time, Mode. The detector will wait for external synchropulse before spectrum registration. Next readouts will be performed without no intervals
	Registration is performed in accordance with pre-set values Exposure time, Mode after receiving synchropulses from external devices

Parameters of generated sync pulses	
- Polarity	Positive
- Amplitude, V	3-5
- FWHM duration, μs	≤10
Requirements to external sync pulse	
- Polarity	Positive
- Amplitude, V	3-15
- FWHM duration, μs	5-20
- Rise time, μs	≤1

Current Spectra Panel

Fig. 19 Current Spectra panel

Undo last zoom / Pan	Return to previous zoom
Unzoom	Un-zoom. Shows the whole spectrum in display area
Zoom In	Zoom in (or mouse wheel scroll-up)
Zoom Out	Zoom out (or mouse wheel scroll-down)
Zoom Vertical min-max	Automatic Y-axis scaling. By checking this option the final value of the Y-scale always equals the maximum intensity value within the viewport of the active spectrum while its initial value always equals the minimal intensity value within the viewport of the active spectrum
Zoom Vertical zero-max	Y-scaling from 0 to the maximum intensity within the viewport
Lg	Show Y-axis data in logarithmic scale
Show / Hide cursor	Select the mouse cursor operating mode: *Points* – the cursor can be placed only on data points *Free* – the cursor is moved freely within the Current Spectra window *Hide* – no cursor is displayed
Show / Hide Points	Show / hide spectrum data points (See Chapter IV)
Show / Hide markers	Show / hide data markers (See Chapter IV)
Pin spectra	Pin the current spectrum to the screen. The function works at continuous registration as well. (See Chapter IV)
Peak info	Show Peak Info (See Chapter IV)
Copy	Copy to clipboard: *Copy data* – copy spectrum data to clipboard as text *Copy image* – copy the Current Spectra image to clipboard
Export	Export data: *Export CSV* – export data in CSV format *Export image* – export the Current Spectra viewport as an image
Print	Print the currently displayed spectrum
	Select units of measurement for X-axis: nm, eV, Raman shift, cm^{-1} or pixels

Mouse control within Current Spectra panel:

Place the mouse cursor on the X-axis or Y-axis, the cursor will take the shape of ↔ or ↕ respectively. Hold down the left-mouse button and drag the mouse up/down to change the Y-axis scaling or left/right to change the X-axis scaling.

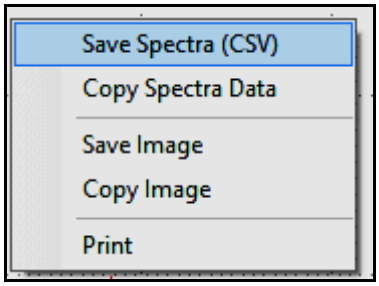
Place the mouse cursor within the spectrum viewport and hold and drag the left-mouse button to select a square area to zoom in.

Place the mouse cursor within the spectrum viewport and hold and drag the right-mouse button for simultaneous Y-axis and X-axis scaling.

Ctrl+mouse wheel – change X-axis scaling.

Shift+ mouse wheel – change Y-axis scaling/

Click the right-mouse button within the spectrum viewport to open the dialogue box:



Save Spectra (CSV) – save spectral data as CSV file.

Copy Spectra Data – copy spectral data to clipboard as text.

Save Image – save spectrum as image (PNG or BMP).

Copy Image – copy the image of the current spectrum viewport to clipboard.

Print – print the current spectrum viewport.

2D image panel

If you select 2D image operating mode and record a spectrum, 2D image panel will store a 2D image of recorded signal with a height of a detector. 2D image panel contains the following control button

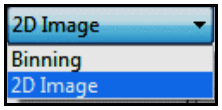
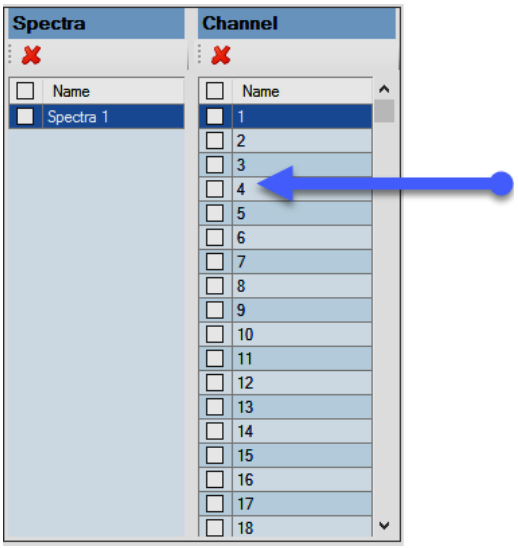


Fig. 20 2D image panel

Unzoom	Un-zoom
Zoom In	Zoom in (or ctrl + mouse wheel up)
Zoom Out	Zoom out (or ctrl + mouse wheel down)
Brightness	Adjust the brightness of image
Copy	Copy to clipboard: *Copy image* – copy to clipboard the current spectrum window *Copy data* – copy to clipboard the spectrum data in .txt format
Export	Export data: *Export image* – export the current spectrum window in image format *Export CSV* – export the spectrum data in .csv format

A spectrum from each channel of height of an array detector will be stored to *Data panel – Channel box.*



Data Panel

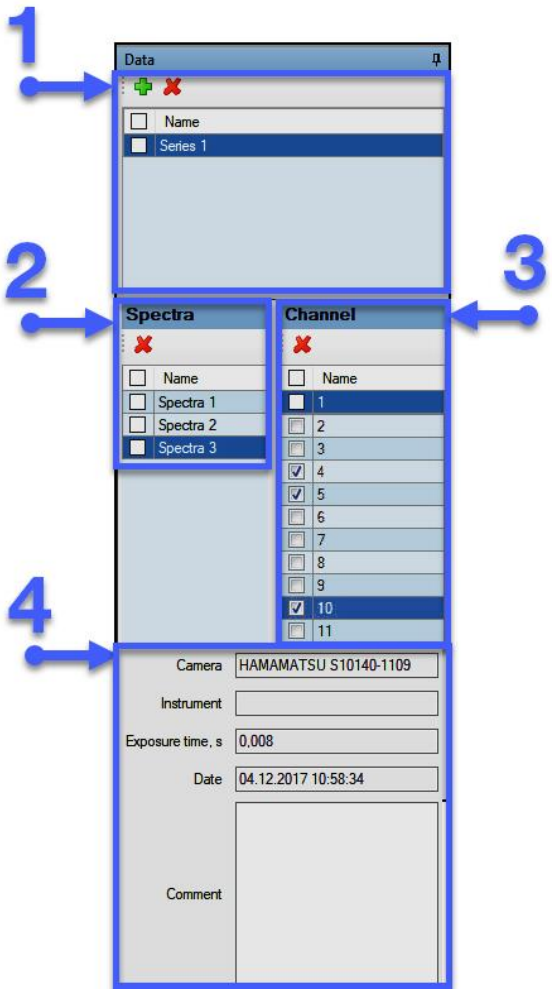


Fig. 21 Data panel

1. *Series* box contains a list of measurement series. Every series is related with a list of certain recorded spectra, which are store in *Spectra* box. New series are added by clicking the  (*Add Series*) button. The tagged series can be deleted by clicking the  (*Delete Series*) button.

2. *Spectra* box contains a list of recorded spectra. Click on the designation of a spectrum to make it active and to display it in the *Current Spectra* panel. The tagged spectra can be deleted by clicking the  (*Delete Spectra*) button.

3. For Binning operating mode every spectrum is associated with one channel in Channels box. For 2D image operating mode every recorded spectrum is also associated with single spectra from channels that produce a height of an array detector. Spectra for each channel can be deleted by marking them and clicking the  (*Delete Channel (s)*) button.

4. Every recorded spectrum will have a general information containing the used camera, device, exposure time and date of record. You can add additional information in *Comment* field.

IV. SolarLS.LAB Routine Operations

To set the monochromator to a required output wavelength:

Within ***Instrument-Wavelength-Target,*** enter the desired output wavelength value in nanometers.

Click  or  . The output wavelength of your monochromator will be set to a value, typed in ***Target*** field, and the ***Current*** display field will take on the value of the ***Target*** field.

To set the required width of the entrance or exit slit:

Within ***Instrument– Entrance slit (or Exit slit)-Target*** enter the required slit width in micrometers.

Click  or  . Once the required slit width has been set, field **Current** will take on the value of the field ***Target***.

To record a single spectrum:

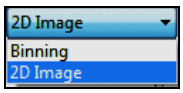
Check all required monochromator settings in **Instrument** panel. Check all camera settings in **Camera Settings** panel. Click  button on the main panel to start a single registration with pre-set values.

To start continuous registration:

Check all required device settings in **Instrument** panel. Check all camera settings in **Camera Settings** panel. Click  button on the main panel to start a single registration with pre-set values. To stop the registration click the  button on the main panel. The last frame will be stored to **Data panel**.

Camera operating mode selection:

To select the operating mode of the camera, open the drop-down list located on the main panel:



Binning – hardware binning mode. It is the basic mode of operation of both linear and array detectors. When operating with an array detector, this mode allows to increase the overall sensitivity of the system by using the total area of each column of the array as a one pixel of increased height.

2d image – two-dimensional image mode. Used for array detectors. This mode allows you to separately read the signal from each pixel, thus providing a resolution for the height of the detector perpendicular to the direction of dispersion.

To pin the spectrum on the screen:

Press the button  (*Pin spectra*) on the Current Spectra panel. This function works at continuous registration as well. You can pin several spectra if required. Click on the arrow near the Pin spectra button to view the list of the pinned spectra. Check or uncheck to change visibility. The Remove All button to remove all the pinned spectra.

To start scanning:

Click on the arrow near the  button and select *Scan.* The following window will appear:

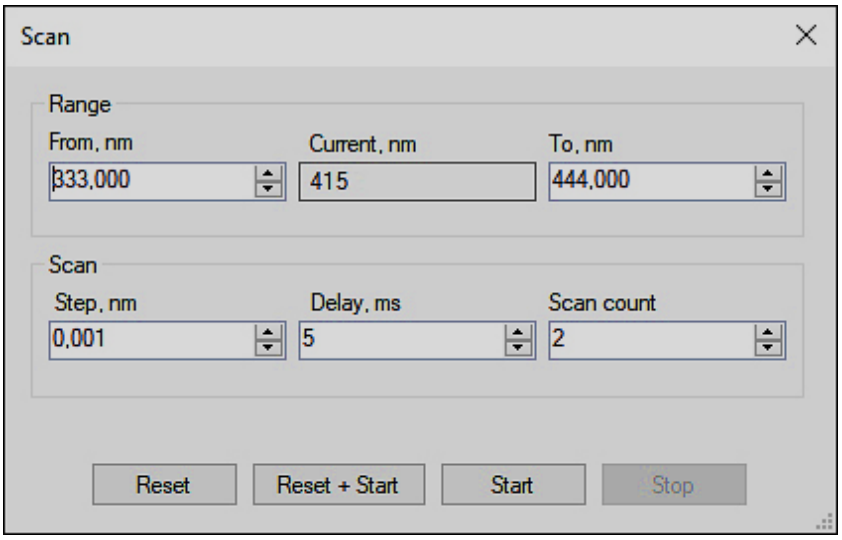


Fig. 22 Scan settings

Input the desired scanning range within in fields **From** and **To**.

The scanning step is set within the field **Step, nm**.

The delay between scanning steps is set within the field **Delay, ms**.

The number of scans is set within the field **Scan count**.

Click **Start** or **Reset+Start** to start scanning.

To record a panoramic spectrum:

The  button click on the main panel opens the following window:

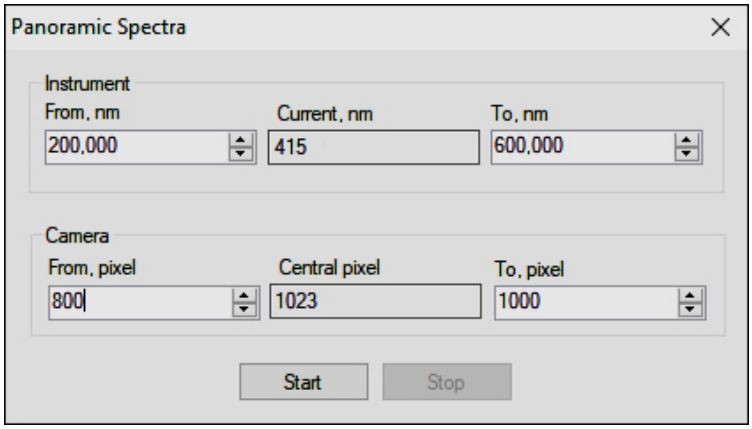


Fig. 23 Panoramic spectra settings

Within this window set the desired scanning range in fields **Instrument-From (nm)** and **Instrument-To (nm)**, click the ***Start*** button, and monochromator will change gratings and filters according to factory settings (if needed, see Fig. 9), record single spectra, automatically link the recorded spectra and display the resulting one. You can also set the range of detector operation within fields **Camera-From, Pixel** and **Camera-To, Pixel**. All detectors have a little non-uniformity of sensitivity on the opposite sides of array. By decreasing the range of active area during scanning, you can make this effect less significant. The resulting spectrum will be stored to Data panel, with a name, containing the word “Scan” and the range of scanning.

Working with data points and markers:

When you click within «Current Spectra» control bar, data points that correspond to each pixel will be displayed on the recorded spectrum.

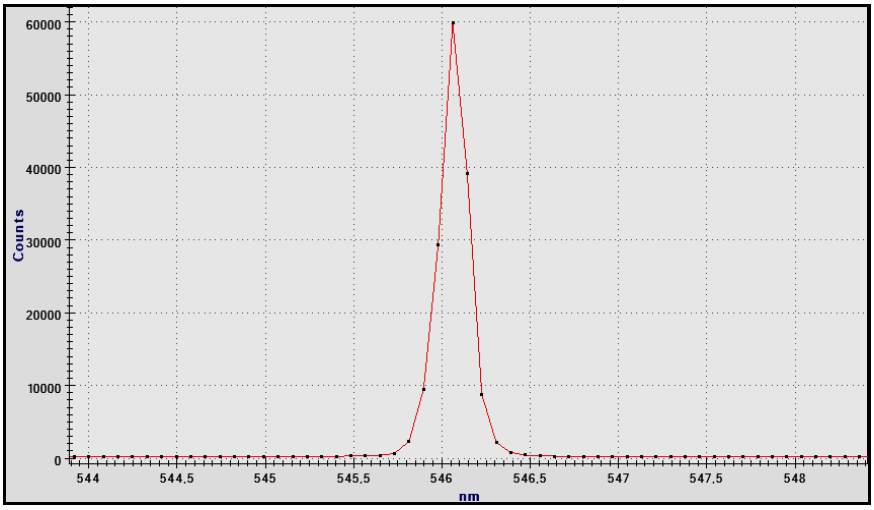


Fig. 24 Example of data points indication after clicking the button. Every black point corresponds to specific pixel of the detector

Click within «Current Spectra» control bar. Place the left marker (A) by clicking the left-mouse button, and then place the right marker (B) with the right-mouse button click. The marker data table will be displayed within the Current Spectra window. This field contains data of X-axis (wavelength), Y-axis values (relative intensity in ADC counts) and a corresponding pixel number of markers A and B. The field Δ contains a shift value between X-values, Y-values and pixel numbers of markers A and B.

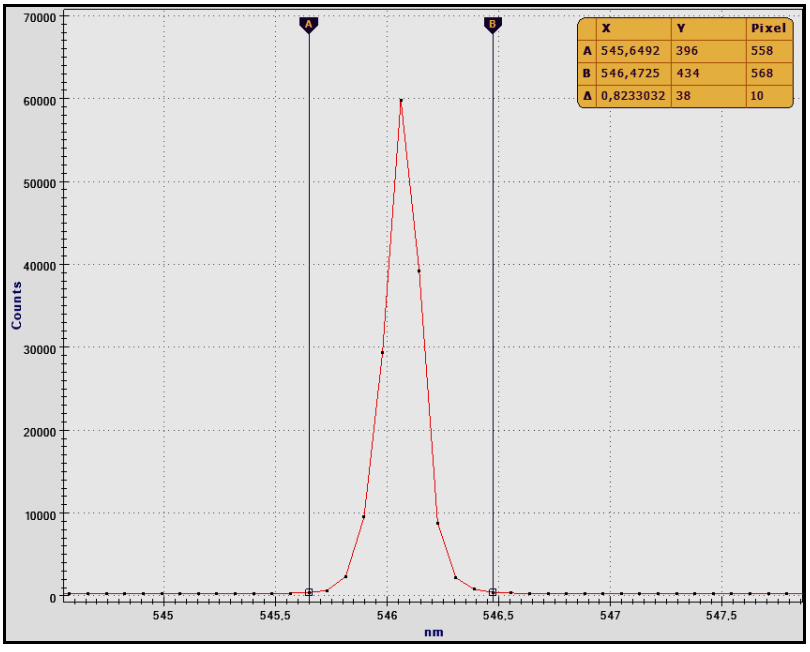


Fig. 25 Marker operation example

Peak info:

If the recorded spectrum contains lines, you can get information about the recorded peak. First, set the edges of the line with markers A and B. Then click  within the «Current Spectra» control bar. The tab **«Peak info»** will appear on your screen:

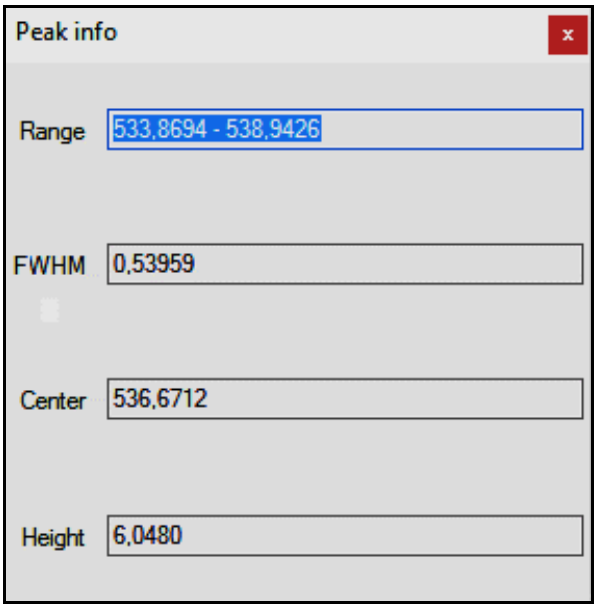


Fig. 26 Peak info tab

The approximated peak will be plotted in blue color within the markers range.

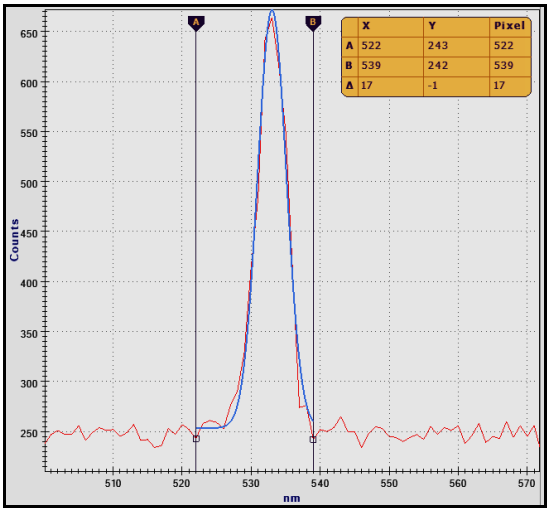


Fig. 27 The plotted peak (blue one)

Peak info tab contains the following information:

Range – this box contains the marked range for peak search.

FWHM- shows the calculated full width at half maximum for the plotted peak.

Center – show the wavelength of peak maximum

Height – shows the relative intensity of the peak.

If the approximated peak is not adequate to the recorded one, try to set markers A and B with more precision. The Peak Info function is intended only for single peak analysis.

Filtering and smoothing

In *Data-Spectra* click on the spectrum name to make in active. To open the *Filtering window* click  on the main panel. In this window the original spectrum is colored in *red*, and the smoothed spectrum is colored in *blue*.

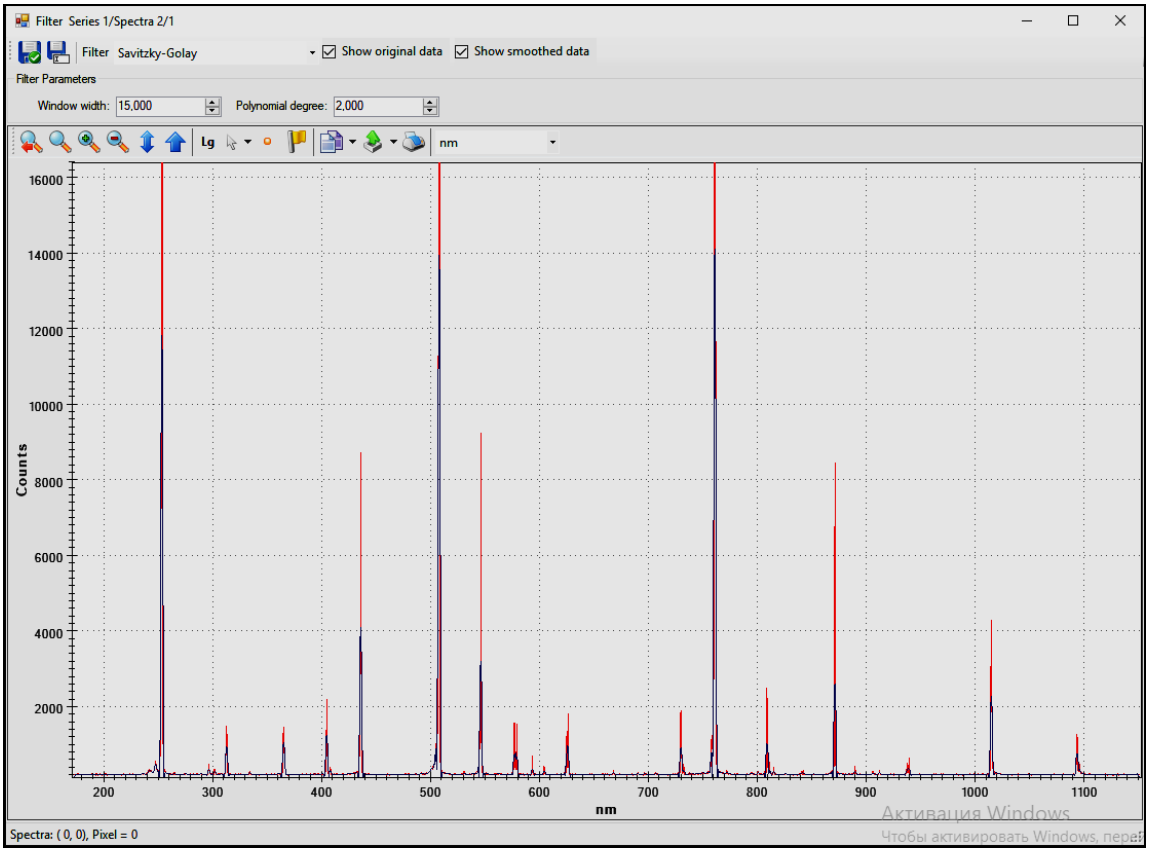


Fig. 28 Filtering window

The upper part of this window contains the following buttons and settings:

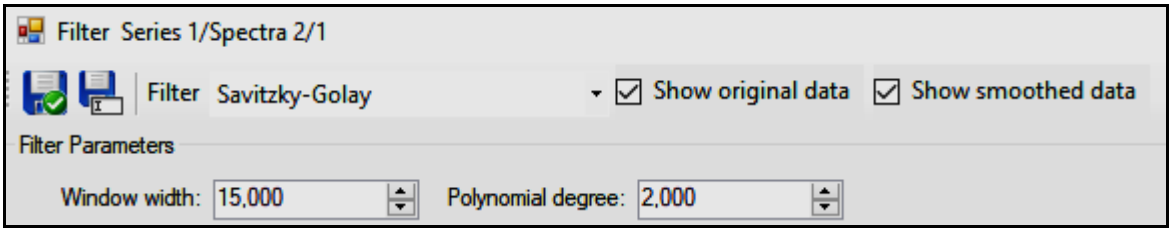


Fig. 29 Filter settings

Filter Savitzky-Golay	Open the drop-down list to select the type of the smoothing filter. The short description of available filters is represented in *Appendix C*.
Show original data	If checked, the original spectrum will be plotted in red color in the Filtering window
Show smoothed data	If checked, the smoothed spectrum will be plotted in red color in the Filtering window
Filter Parameters	This tab holds the settings for the active *Filter*

Saving smoothed spectra

After clicking the button  (*replace original spectrum with smoothed spectrum*), the original spectrum in *Data panel* will be replaced with the smoothed spectrum.

After clicking the button  (*save as*), the following window will appear:

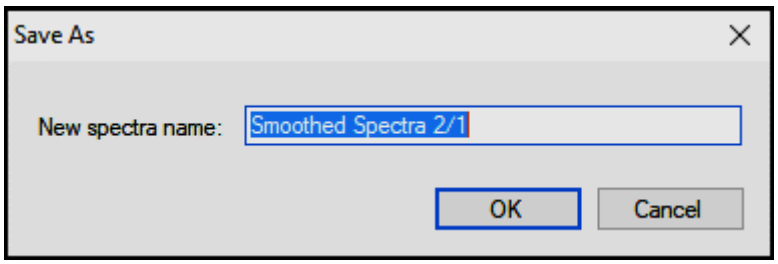


Fig. 30 Saving the smoothed spectrum under a new name

Type the name for the smoothed spectrum and click «*Ok*». The smoothed spectrum with a new name will stored to *Data-Spectra:*

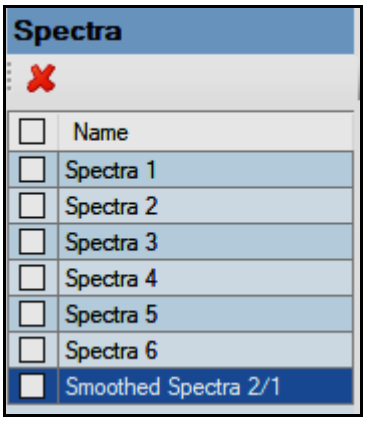


Fig. 31 Saved smoothed spectrum

The short description of available filters is represented in *Appendix C*. More detailed information can be found in the dedicated literature or Internet.

Camera Calibration

Wavelength Calibration

Wavelength calibration is unique for each spectrometer; it is stored in the calibration file XXXX_.wclbr (XXXX – serial number of the spectrometer). Wavelength calibration is set automatically during the software installation on your PC from the supplied USB-drive.

In the course of time and under the influence of environmental temperature fluctuations the calibration curve of a particular spectrometer can be slightly shifted. In such case, it is recommended to perform correction of the calibration curve.

Click  within **«Camera Settings»** panel to observe or change the calibration. The following window will appear:

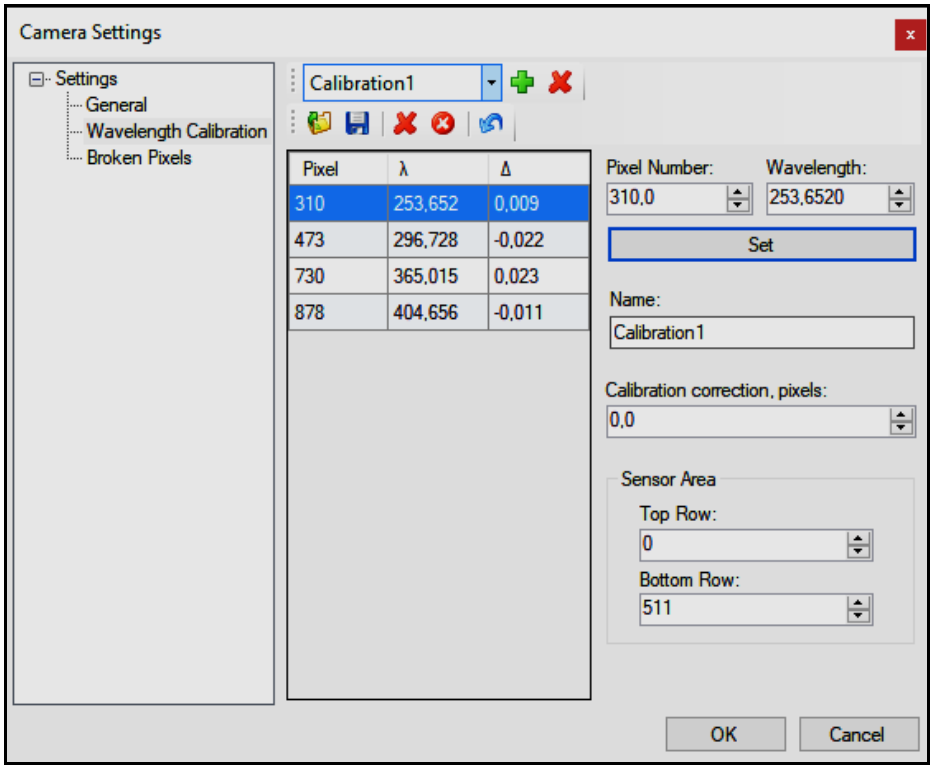


Fig. 32 Wavelength calibration window

Open	Load calibration from file (.TXT or .WCLBR)
Save	Save calibration to file to .WCLBR format
Delete point	Delete the selected reference point from calibration
Delete all	Delete all reference points from calibration
Restore original calibration	Restore the initial calibration
Add new calibration	Add new calibration
Delete current calibration	Delete current calibration

Sensor Area*

** - intended for array detectors.*

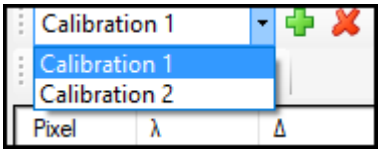
Set a ***Top Row*** and ***Bottom Row*** values to set active vertical range of array detector operation.

Adding new reference point to calibration

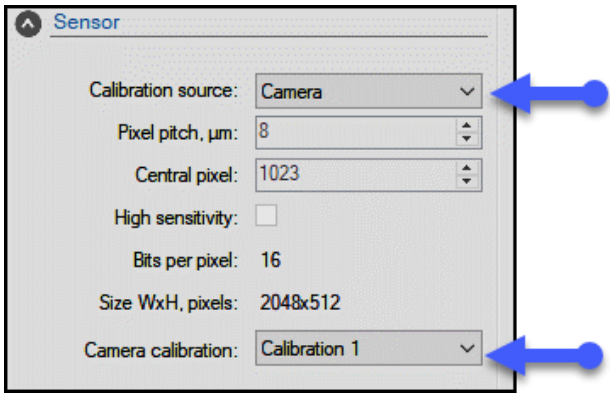
To add a new reference point to the current calibration, enter the **pixel number** and the corresponding **Wavelength** in nanometers. Click the ***«Set»*** button to add a new reference point to the calibration. The selected calibration points can be deleted by pressing the  *(Delete point)* button. The entire table of values can be deleted by clicking on the  *(Delete all)* button.

Adding new calibration

The **Name** field displays the name of the current calibration, and it can be changed. You can also add a new calibration file by clicking the  button in the *Camera Settings tab - Wavelength Calibration*. The list of available calibrations can be viewed by opening the drop-down list:



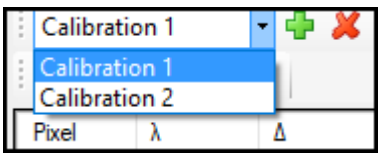
The active calibration is selected in the *Camera Settings - Sensor - Camera Calibration*:



 ***Make sure that "Camera" is selected in the Calibration source list.***

Deleting the calibration

The list of available calibrations can be viewed by opening the drop-down list:



The calibration selected from the list can be deleted by pressing the  *(Delete current calibration)* button.

Calibration correction

To correct wavelength calibration it is sufficient to use a light source with one known spectral line that lies within the spectral range of your spectrometer. This can be, for example, a Mercury line 546.073nm, which is available in any daylight lamp.

- register a spectrum from the light source and make sure that the intensity of the spectral line chosen for correction is within the Y-axis of the «Current Spectra» window,

- with the cursor, mark a display point corresponding to the maximum intensity of the selected spectral line,

- log a wavelength value measured with the S100 spectrometer on the X-axis and compare it to the table value of the selected spectral line.

- in case of wide disagreements click  within **«Camera Settings»** to open **«Wavelength Correction»** window. Here you can set the parallel shift to whole calibration curve by a number of entered pixels (from -100 to 100) in this box. According to +\- sign the shift will be made to the left or to the right. Press OK to apply calibration correction for next spectra recordings.

- Check if the measured wavelength corresponds to the table value; if necessary, repeat the correction procedure until the best match.

Wavelength recalibration

For wavelength recalibration it is required to have a light source with several spectral lines (preferably 10-20) uniformly distributed along the spectral range of your spectrometer. These can be, for instance, a mercury or mercury-argon lamp, or neon and krypton lamps.

In case your spectrometer is not equipped with an order separation filter, you can use second, third or higher orders of spectral lines for calibration, whereas these lines are within the spectral range of your spectrometer.

- register the light source spectrum and make sure intensity of selected lines is within the Y-axis of the «Current Spectra» window,

- with help of the cursor, mark points on the display which correspond to the maximum intensity of selected spectral lines and log the corresponding pixel numbers along the X-axis,

- Click  within **«Camera Settings»** to open **«Wavelength Correction»** window (Fig.32). Create a new calibration by clicking the  (*Add new calibration*) button. Type in the boxes the **pixel number** and the corresponding **wavelength** in nanometers. Click ***«Set»*** to **add a new ranging mark** to calibration.

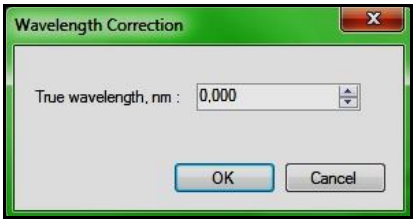
- save the new calibration file to .wclbr format by clicking  within **«Wavelength Correction»** window.

- after finishing the calibration procedure press the button OK.

If you apply your own calibration, it is recommended to reserve the manufacturer's calibration file as a backup.

Wavelength Correction

To ensure maximum accuracy of the device operation make use of the wavelength correction procedure. When you click the  button on the Instrument Panel, the following window will appear:



When you type the value of *True wavelength* in the input box and click the “OK” button, the current wavelength (displayed in Instrument-Wavelength-Current) will be corrected to the typed value evoking the same shift for X-axis.

To get full description of wavelength correction procedure for your device adhere to the User’s Manual of your instrument

Appendix A. Customizing the interface

The main panel is locked in the upper part of the software. Location, size and view mode of any other panels can be customized.

For example, in Fig.29 Camera Settings panel and Instrument panel are located in one window. Place the cursor on Camera Settings tab and hold the left-mouse button. Hold and drag the mouse to place Camera Settings panel in any other convenient location, then release the left-mouse button.

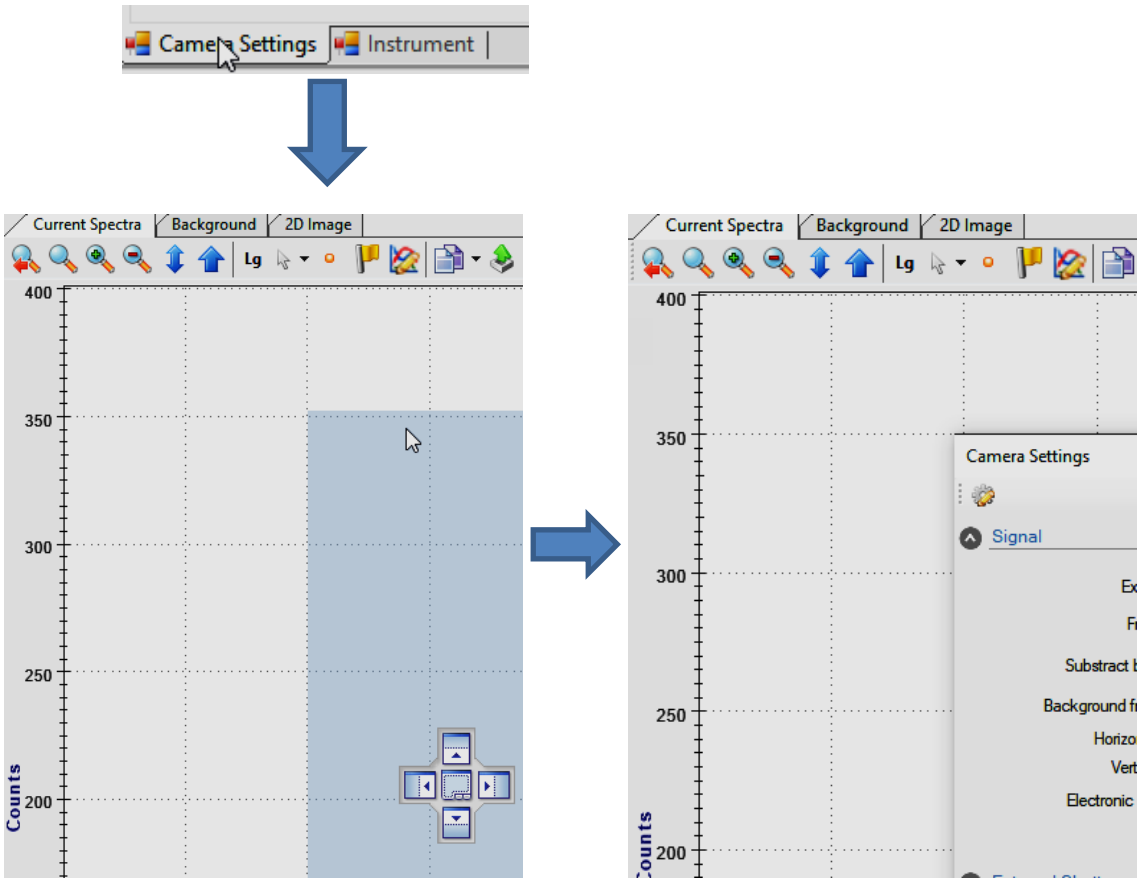
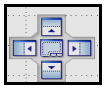


Fig. 33 Dragging the panel

If you drag the panel to any other panel the following symbols will appear on the screen  If you place the dragged panel on these pointers up/down/left/right it will located up/down/left/right relative to the selected panel. If you place the dragged panel on the central pointer, the selected window will start to contain tabs of the previous panel and the new one.

If you hold and drag the panel to the edge of the screen by placing it on the appearing pointer (for example,  near the right edges of the screen and then click  , the panel become «hidden». It can be viewed by placing the cursor on the dropped-down tab.

Appendix B. Good practices of panoramic spectra recording

1. Set the required diffraction grating and select the port with the detector as active. Make sure, that the shutter is opened.
2. Set the monochromator to wavelength equal to the blaze wavelength of the active diffraction grating.
3. Start the continuous registration by clicking the  button. Observe the recorded signal in ***Current Spectra*** panel and adjust the entrance slit width in such way, that the signal would be 80-90% of maximum camera saturation.

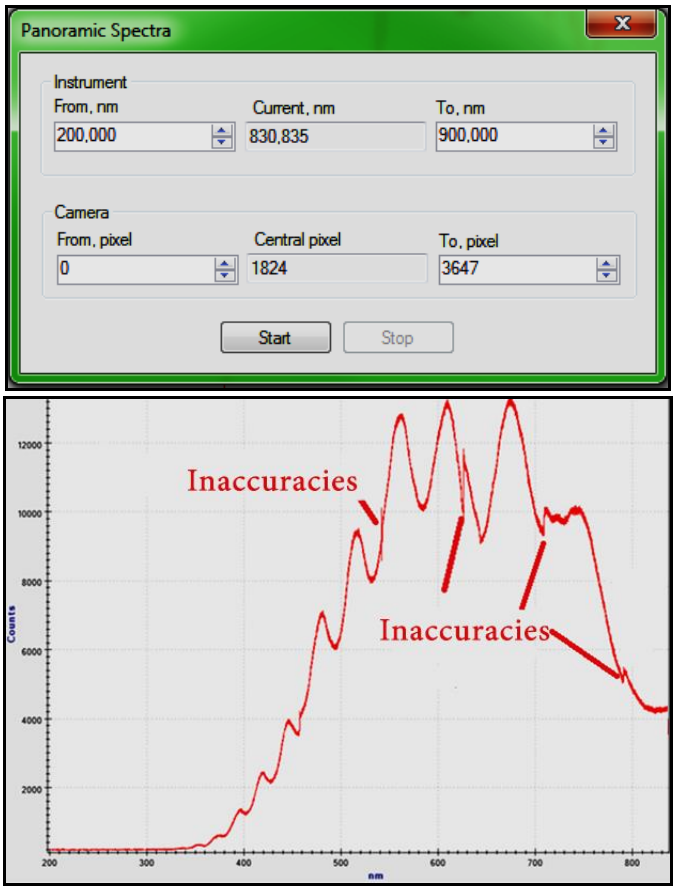
For operation with the line radiation sources adjust the signal by the maximum of the line amplitude with the help of detector position alignment screw (adhere to «Focusing the detector» chapter in the User's Manual of your monochromator. For operation with continuum radiation sources the detector focusing is not required.

4. If you can't achieve the desired signal level by entrance slit width adjustment, change the exposure time parameter in **Camera Settings-Signal-Exposure.**
5. Click  on the main panel. In the newly opened window set the range of scanning. We will scan the range 200-900 nm in this example.

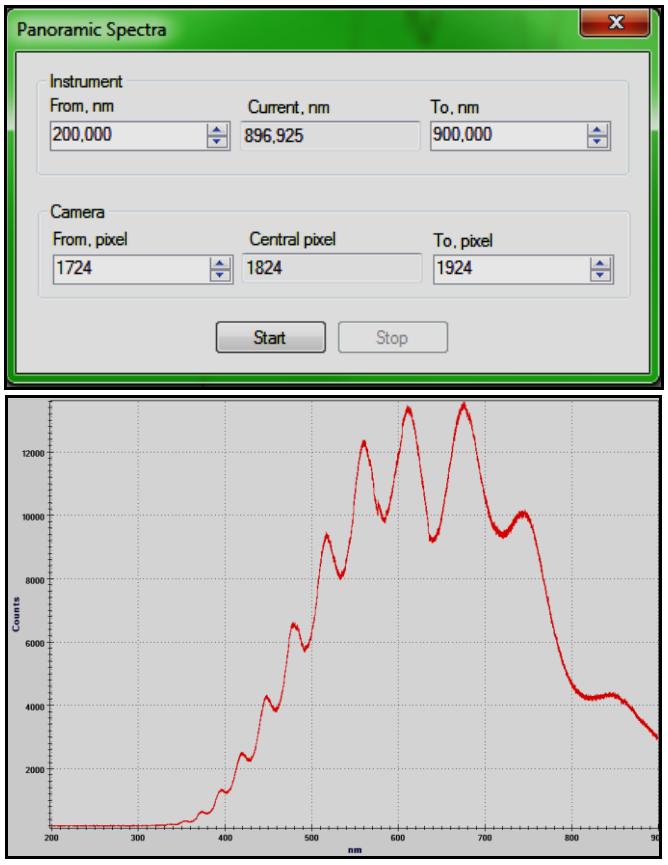
6. In entry fields **Camera-From, Pixel** and **Camera-To, Pixel** set the range of detector operation. In this example, we will try two different settings: 1) we will use all detector pixels from 0 to 3647; 2) we will use pixels from 1724 to 1924 (the index of central pixel is 1824). You can see in figures of recorded panoramic spectra below that the second setting is more preferable. The values of range of detector operations are picked up experimentally.

7. Place checkmarks in instrument configuration editor to set automated switch of gratings and filters dependent on the output wavelength of monochromator (see Fig. 10).

8. On the next page you can find the comparative results of the recorded panoramic spectra with different settings.



All pixels are used. The resulting panoramic spectrum has several inaccuracies after linking.



Range of used pixels from 1724 to 1924 (index of central pixel – 1824). The resulting panoramic spectrum almost does not have any inaccuracies after linking.

Appendix C. Types of smoothing filters

This Appendix holds the short description of the available smoothing filters in SolarLS.LAB software.

In *Data-Spectra* click on the spectrum name to make in active. To open the *Filtering window* click  on the main panel. In this window the original spectrum is colored in *red*, and the smoothed spectrum is colored in *blue*.

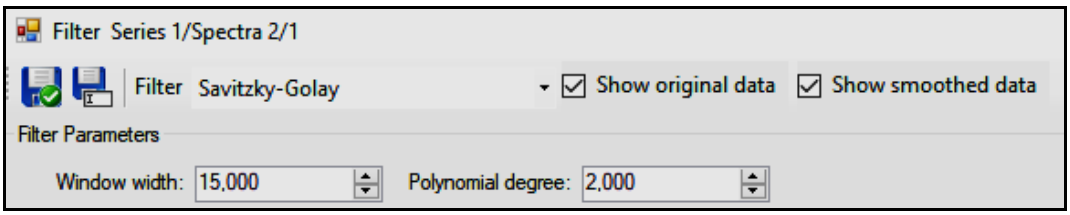
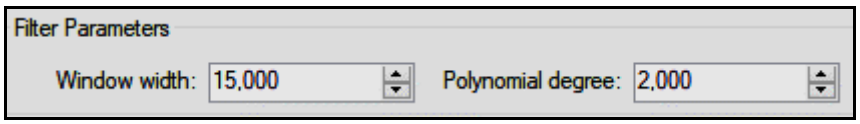


Fig. 34 Filtering settings

Open the drop-down list  to select the required smoothing filter

Savitzky-Golay Filter



The Savitzky-Golay filter holds the following parameters to be set for evaluation: *window width* – the number of analytical points of the spectrum; and *Polynomial degree*.

Discrete Wavelet Filter

Select on the wavelets in the drop-down list *Wavelet type*:

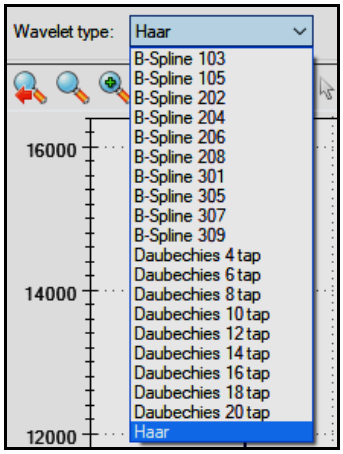


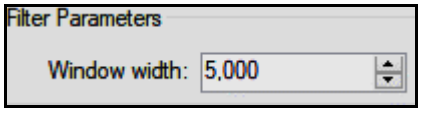
Fig. 35 Available wavelet types

Threshold – the threshold value of the function is set for filtering.

Hard Threshold – if checked, only small in absolute magnitude wavelet coefficients will be corrected to zero, this will save the signal amplitude undisturbed, but it will lead to appearance of irregularities. “Soft” threshold, when unchecked, allows to avoid irregularities, but all wavelet coefficients are corrected and the amplitude of the signal is reduced.

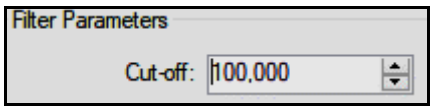
Spectra filtering with wavelet transform is recommended for spectra with many lines and for the effective correction of noise signal.

Moving average/boxcar Filter



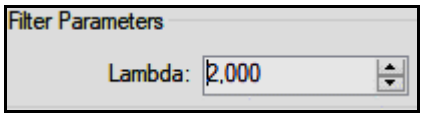
The settings for moving average filter hold the following parameters to be set for evaluation: *window width* – the number of analytical points of the spectrum.

Butterworth Filter



The settings for Butterworth filter hold the *Cut-off value* to be set for evaluation.

Whittaker smoother



The settings for Whittaker filter hold the *Lambda value* to be set for evaluation.

Convolutions Filters

List of available convolution filters:

Gauss, Bartlett, Bartlett-Hann, Parzen, Welch, Sine, Hann, Hamming, Blackman, Blackman-Harris, Blackman-Nuttal, Exponential, Kaiser, Flat Top, Lanchos

The settings for convolution filters hold the following parameters to be set for evaluation: *window width* – the number of analytical points of the spectrum. The *Gauss, Exponential and Kaiser* filters have extra parameters to be set.

The detailed information about smoothing filters and accompanying math is available in the dedicated literature and on the Internet sources.

Appendix D. Intensity calibration

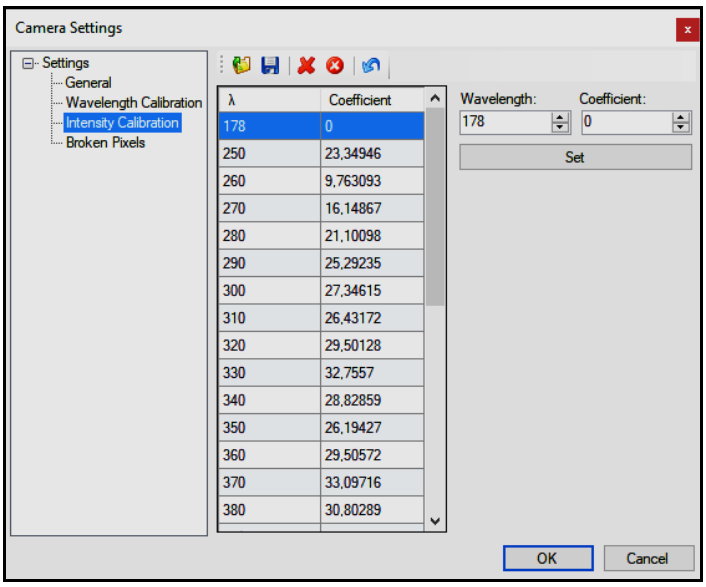


Fig. 36 Intensity calibration tool

Proceed to the **«Camera Settings»** - click the  button on the *Camera Tab* – open the *Intensity calibration* tab. Here the intensity correction coefficients are stored in case if the factory intensity calibration was optionally purchased. These coefficients are used to re-calculate the ADC count to absolute spectral irradiance if the appropriate box is checked on *Camera tab.* You can produce your own table, load it and use it.

 ***Open***	Load calibration from file (.TXT or .ICLBR)
 ***Save***	Save calibration to file to .ICLBR format
 ***Delete point***	Delete the selected reference point from calibration
 ***Delete all***	Delete all reference points from calibration
 ***Restore original calibration***	Restore the initial calibration

Appendix E. Colorimetry

On the main panel, click *View-Colorimetry*. The *Color panel* will appear on the screen. This panel contains the results for chromacity coordinates, correlated color temperature, CRI and CIE CAM02 indexes calculated for the active selected spectrum on the *Data panel*. The standard observer may (2° or 10°) may be selected in the dropdown-box *Observer*. The dropdown-box *Color Space* allows selecting of the active Color space (CIE 1931, CIE 1960 or CIE 1976).

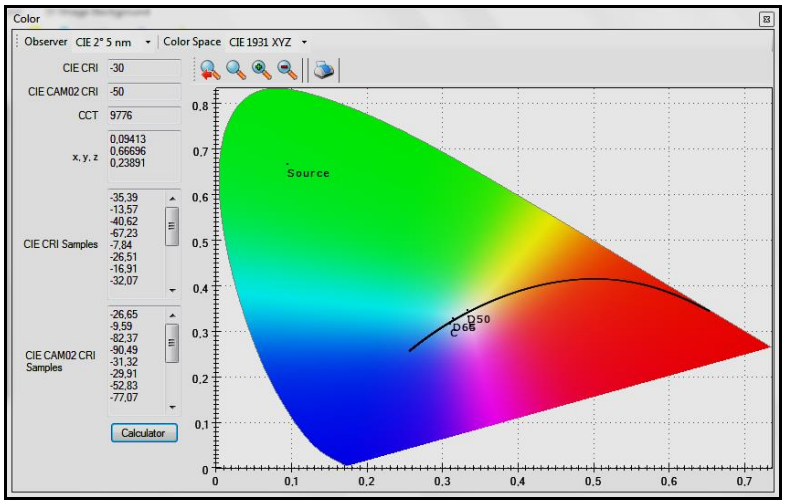


Fig. 36 Color panel – colorimetry calculations

The panel plots the active color space, the black body curve, several reference standard illuminative sources (C, D50, D65) and the Source point, that relates to the measured light source.

Color calculator

On the main panel, click *View – Color Calculator* to open the large tool-calculator of color coordinates:

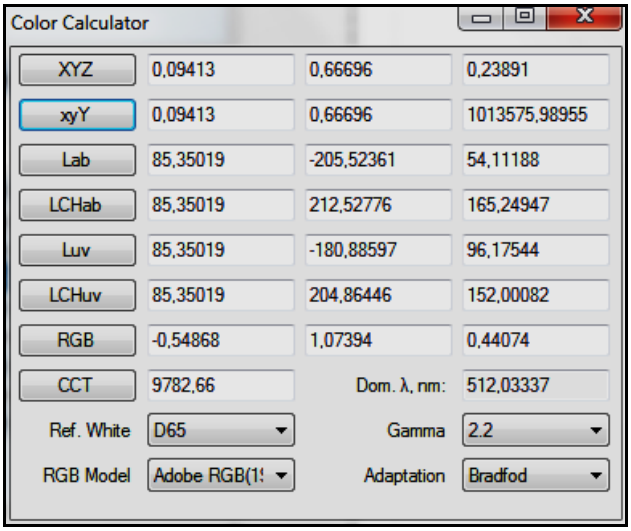
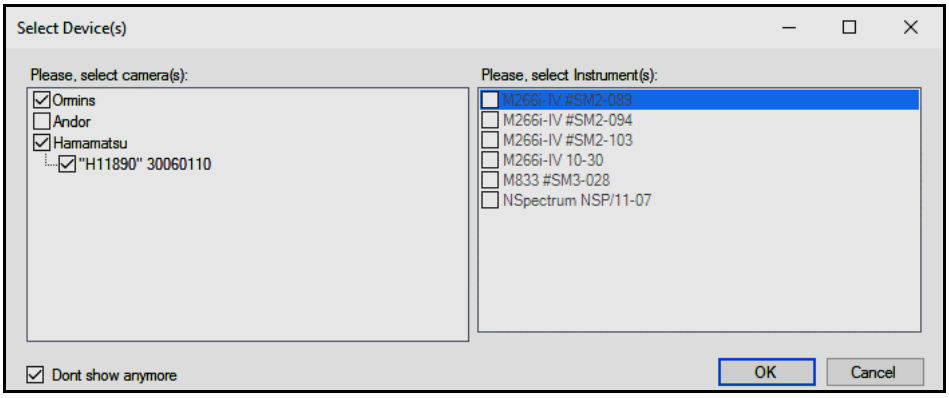


Fig. 37 Color calculator

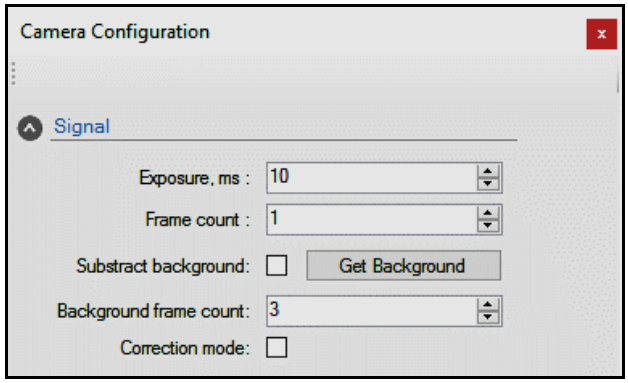
The columns xyY will hold the coordinates, calculated for the active spectrum in Color panel (x,y,z). Click on the xyY button to calculate the normalized color coordinates in other color spaces.

Appendix F. Operation with PMT

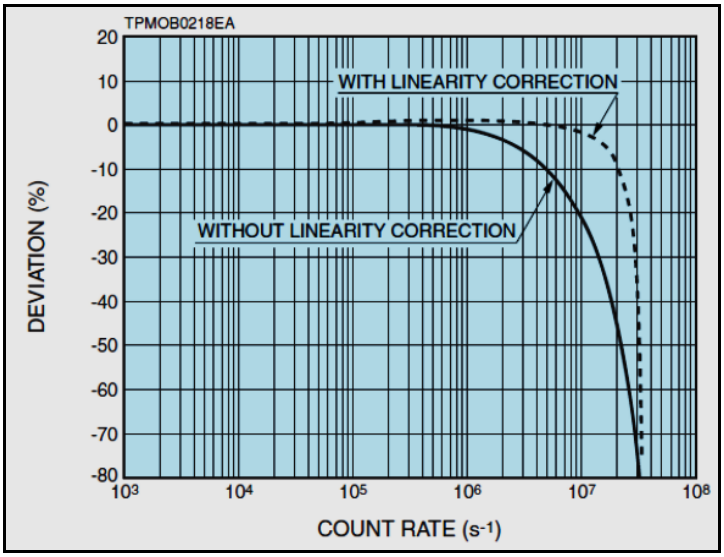
When operating with PMT and photon counters some features of the SolarLS.LAB software will differ. When the PMT is connected to your PC with the USB-cable, click  on the main panel to open the *Device Selection window.* Check the box that relates to connected PMT model and click OK.



The registration parameters for PMTs are located on the panel *Camera-Signal* and are analogous as for the CCDs.



Correction mode - distortion of the output may occure at a large output current,. Click the check mark to compensate this effect.



Appendix G. Operation with detectors by Andor Technology

If you are using detectors by *Andor Technology* the new controlling functions will appear in the *Camera Settings panel*. The set of available functions depends on the detector type.

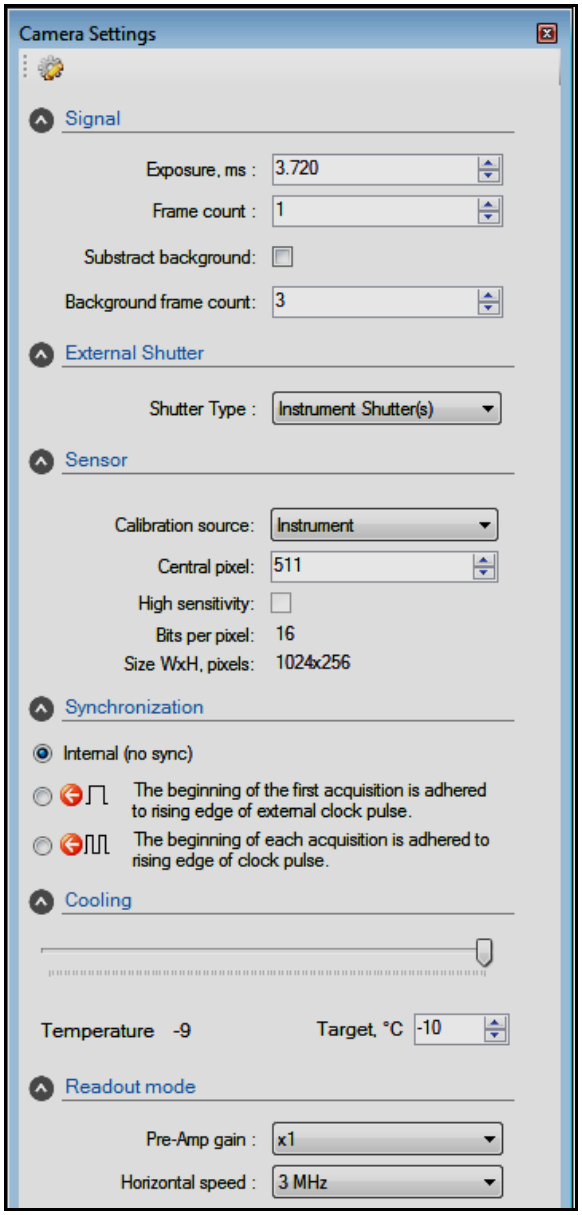


Fig. 38 Operation with detectors by Andor Technology

Cooling	The desired thermoelectric cooling temperature of the Andor detector is set within the *Target* input field (or with the slider).
Temperature	Displays the current cooling temperature
Pre-Amp gain	The signal preamplifier multiplier (for example, x1, x2, x4) is set within this field: the preamplifier option is designed to use the dynamic range of the camera in the most efficient way, while maintaining the optimum signal-to-noise ratio.
Horizontal speed	This field sets the horizontal sampling rate (for example, 3MHz, 1MHz, 0.05MHz). A higher frequency results in faster measurements, but increases the signal-to-noise ratio.