LR1 – compact spectrometer

Version 2.1

Spectral range and spectral resolution can be customized
examples on LabView and VC++ are included in standard configuration
CRI calculation, XYZ color space(*)

Weight:	430 grams
Dimensions:	102 mm x 84 mm x 59 mm
Detector:	Toshiba TCD1304DG linear array
Detector range:	200 – 1100 nm
Pixels:	3648
Pixel size:	8 um x 200 um
Pixel well depth:	100,000 electrons
Signal-to-noise ratio:	300:1
A/D resolution:	14 bit
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand optical fiber
Wavelength and Optical resolution:	Configuration A: **Spectral range: 300 – 1000 nm** **spectral resolution:** **< 1 nm** (with 50 um slit) Configuration B: **Spectral range: 200 – 1200 nm** **spectral resolution:** **< 2 nm** (with 50 um slit) Configuration C: **Spectral range: 560 – 960 nm** **spectral resolution:**

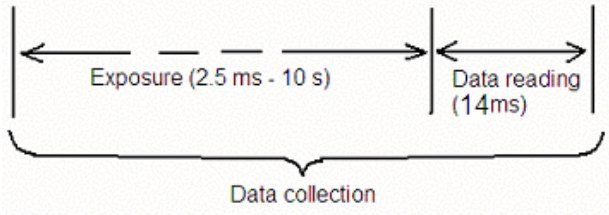
	< 0.4 nm (with 50 um slit) Configuration D: **Spectral range: 300 – 700 nm** **spectral resolution:** **< 0.4 nm** (with 50 um slit) (Spectral range and spectral resolution can be customized)
Exposure time:	2.5 ms – 10 s
CCD reading time:	14 ms
Power consumption:	200mA @ 5V from USB interface
Onboard memory capacity:	64 spectra
Data transfer speed (to on board RAM):	200 ms / 100 ms (2 points binding)
Trigger:	3 modes (in LR1 some trigger modes are optional)
Computer interface:	USB 2.0, HID 2.0 Several spectrometers can be connected to the same comuter
Operational system:	Windows 8 / Windows 7 / Vista / XP / Me / Windows 98; 32/64b
Software:	application software, driver, LabView and VC++ examples
Hardware:	USB cable, 1 meter optical fiber with SMA connectors

(*) Optional
(1) Spectral range and spectral resolution can be customized
(2) In LR1 some trigger modes are optional

Trigger options

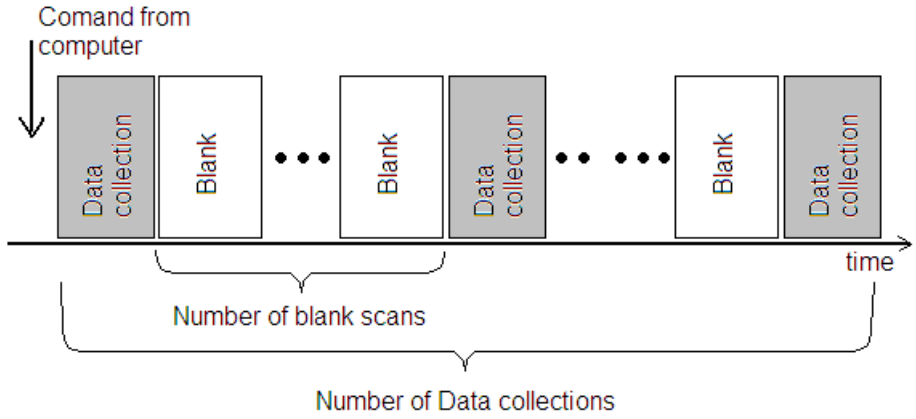
LR1 spectrometer has internal memory SRAM. Memory is able to store 64 collected spectra.

Data collection consists of two stages: exposure and reading and transferring to onboard memory SRAM. Data reading and transferring takes 10 ms.



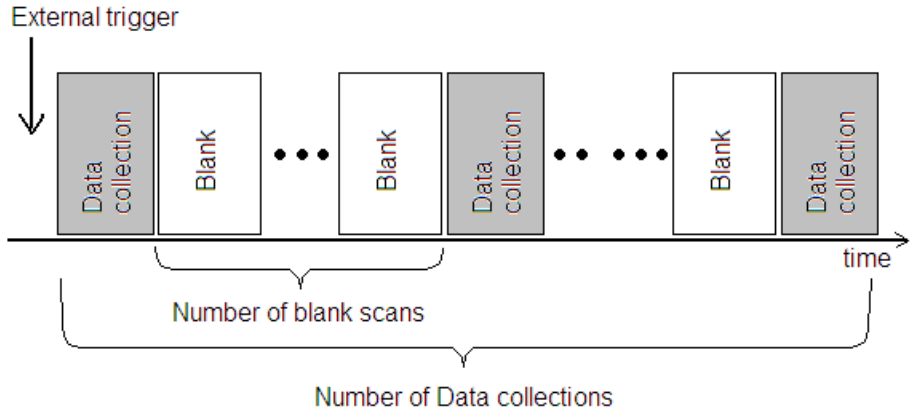
There are three trigger modes available:

a) Data is acquired after getting command from computer without external trigger.

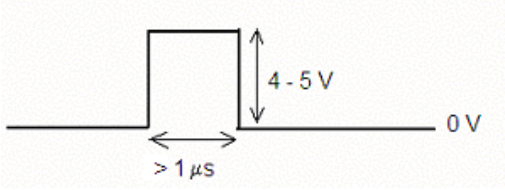


Data collection events are specified. Data collection events are separated by specified equal amount of Blank scans. Blank scan is identical to the real Data collection scan except data is not stored in device onboard memory.

b) Data is acquired after external trigger (optional in LR1)

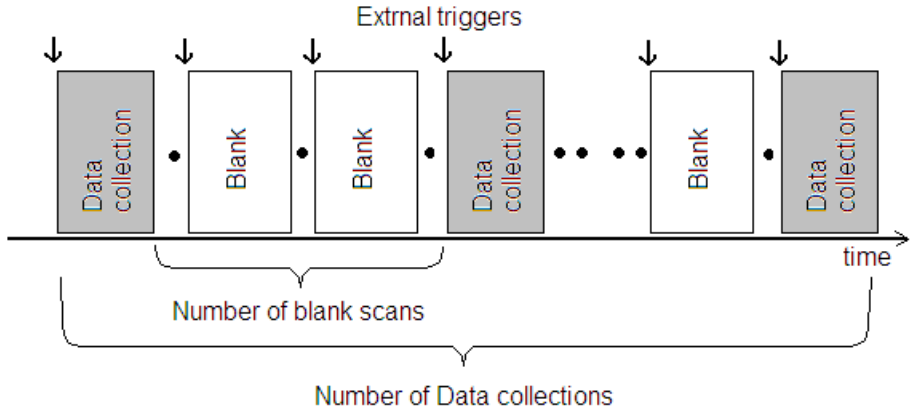


External trigger specifications: TTL pulse, amplitude: 4 – 5 V, minimum duration: 1µs.



This trigger mode can be used to detect system temporal response on some event synchronized with external trigger.

c) Every spectra is collected after external trigger (optional in LR1)



Application software (included in standard configuration)

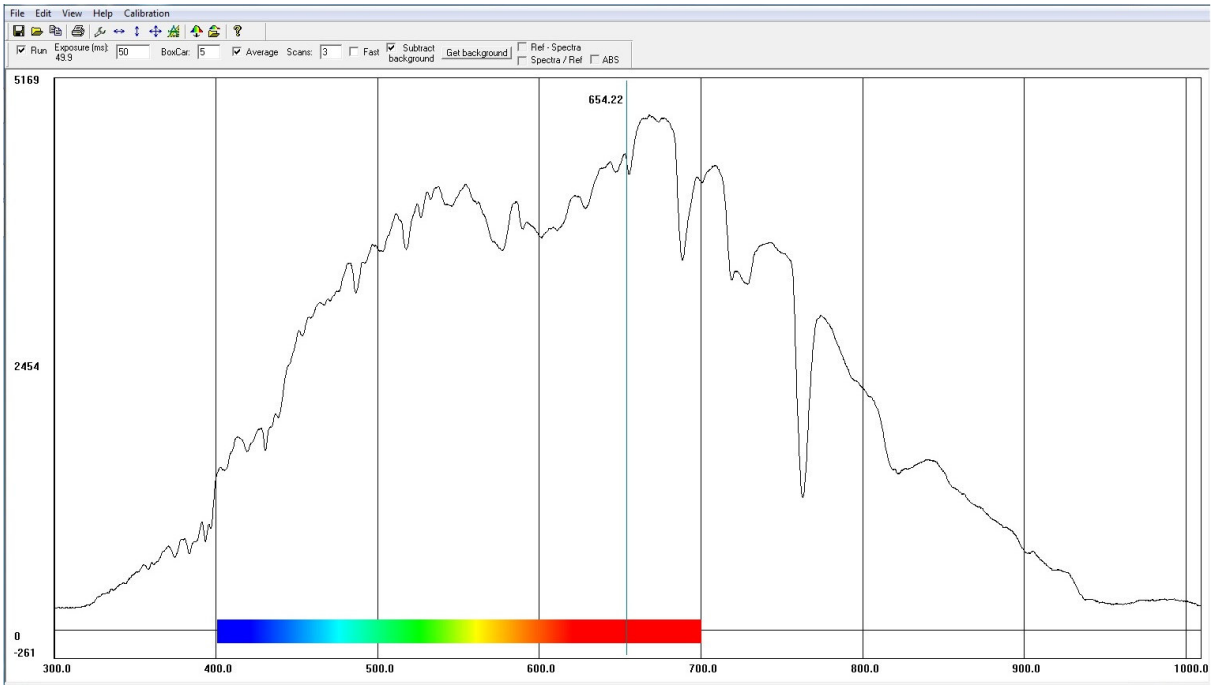
Connection

LR1 is recognized by Windows operational system as standard HID device. That is why there is no need to install any special drivers to use LR1 spectrometer.

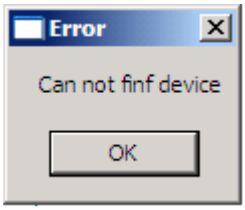
Operational system recognizes device after spectrometer has been connected to USB port. As usually it takes less that one minutes. In the end of this process windows shows message on the Toolbar that device is installed and ready to use.

It is possible to start “CheckTr.exe” program as soon as device is recognized by operational system.

After program is started it reads configuration information including calibration information from spectrometer FLASH memory. Typical view of the program main window:



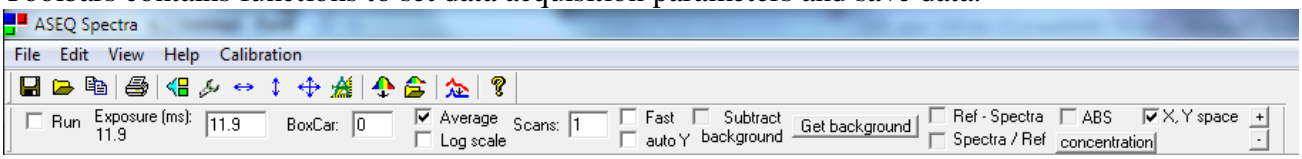
If software can not recognize connected device it shows Error message:



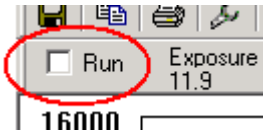
If so check connection and version of the USB port on your computer.

Toolbar

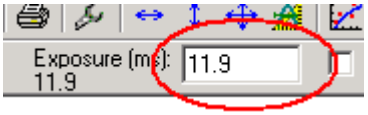
Toolbars contains functions to set data acquisition parameters and save data.



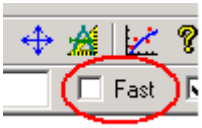
Start data acquisition:

To start data collection check Run:  To stop data collection uncheck it.

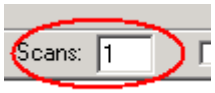
Exposure time:

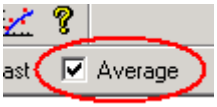
Exposure time (in ms) is set: 

Fast mode:

To increase speed of spectral data transfer and plotting to computer check:  It causes transfer one out of every two consecutive spectral data points. Uncheck it to return to normal data transfer.

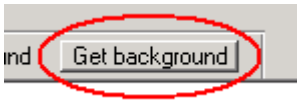
Number of scans and averaging:

To set number of data collections (ref. Trigger options): 



It is possible to plot averaged spectra to increase Signal to Noise ratio:
All spectra specified in “Scans” are plotted if this Check Button is unchecked.

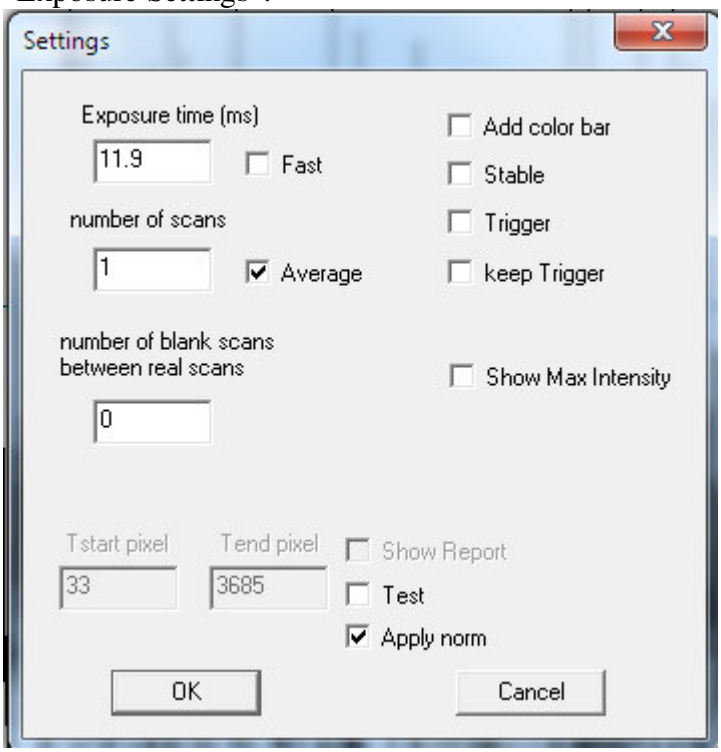
Background:

Push “Get background”  to acquire Background. (We recommend to use average several spectra to get Background with better Signal to Noise level).

It is possible to subtract acquired background:

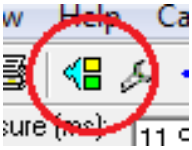
Settings:

Push “Settings” To set exposure parameters and trigger mode. It calls dialog window “Exposure Settings”:



It duplicates controls described previously: “Exposure time”, “Number of scans” (the save as “Scans”), “Fast”. “Show Max Intensity” sets cursor on the point of maximum intensity.
It has control Box to specify “number of blank scans between real scans” (see Trigger options).
Combination of Check Buttons “Trigger” and “Keep trigger” sets one of three trigger options. It sets first trigger regime (no trigger) if both Check buttons are uncheck. If “Trigger” is checked and “keep Trigger” is unchecked it selects second trigger mode. If both Boxes are checked it selects third trigger mode.
Do not change “Test” and “Apply norm”.

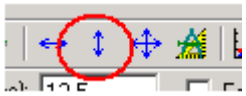
Choose between spectrometers connected to computer:



Button “Choose spectrometer” allows choosing between connected spectrometers

Scaling:

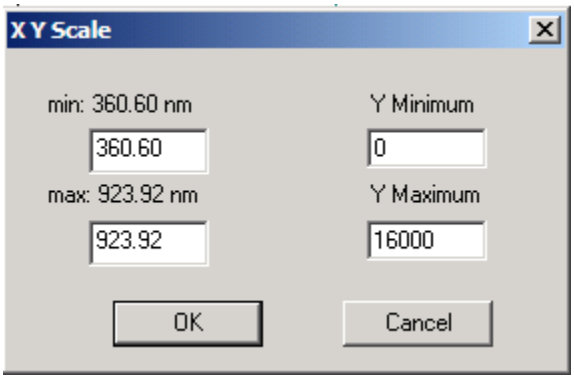
Button “x autoscale” sets horizontal wavelength scale to its maximum values



Button “y autoscale” sets vertical intensity scale to the minimum and maximum of current acquired data.

Button “x and y autoscale” is a combination of previous two.

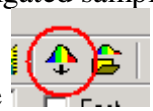
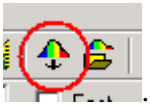
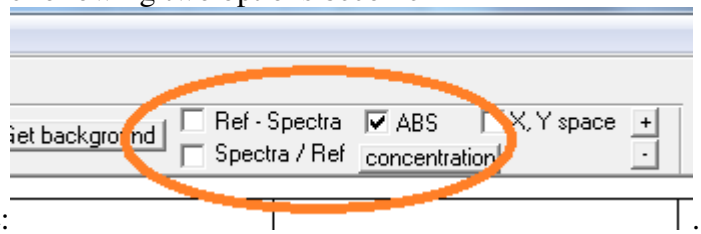
Button “scale”  calls dialog window to set vertical and horizontal scale:



(Note: Picture is representative. Minimum and maximum wavelengths presented here can be different for each device)

The same dialog windows can be called by double clicking on the vertical or horizontal scale of the main window.

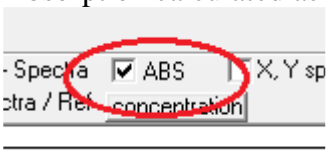
Calorimetric or Transmission measurements:

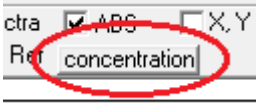
It is possible to measure absolute or relative transmission of investigated sample or use calorimetric calibration data. It is necessary to use current spectra as a reference  or load it from file:  . Full 3712 pixels spectra can be used as reference spectra. After obtaining reference spectra the following two options become available: 

. “Ref – Spectra” allows plotting result of the following mathematical procedure: Reference spectra minus current spectra. “Spectra / Ref” plots current obtained spectra divided on Reference spectra.

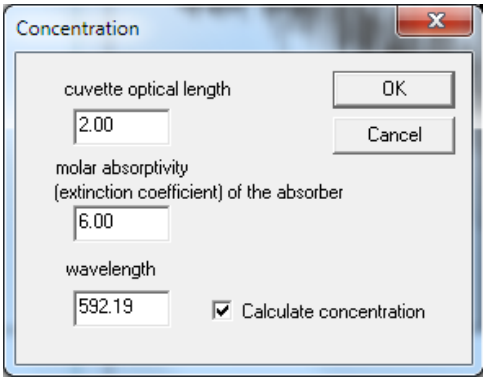
Absorption and concentration measurements:

Absorption calculated as $-\log_{10}$(Spectra / Ref) can be plotted in “ABS mode”:

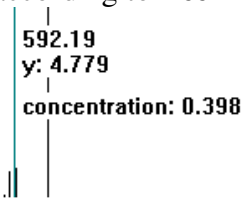


Program can calculate molar concentration of absorbing species in the material. Click “concentration”: 

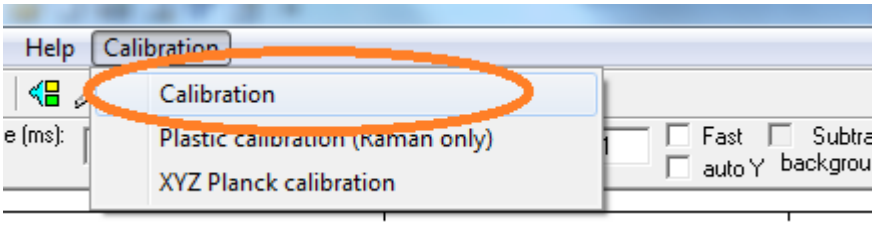
. Program offers to define cuvette optical length, molar absorptivity (extinction coefficient) of the absorber and wavelength to use for concentration calculation:



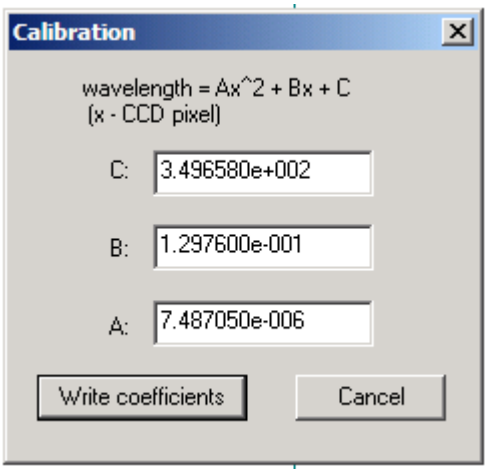
Click "OK". Program will show molar concentration of absorbing species in the material calculated according to **Beer–Lambert–Bouguer law**:



Calibration:



"Calibration" button calls Dialog window. It allows writing new calibrations coefficients (A, B, C) into the FLASH memory of spectrometer. Calibration is done based on third order polynomial approximation (wavelength = Ax^2+Bx+C, where x – CCD pixel number).

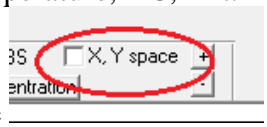


(Note: Picture is representative. Calibration coefficients presented here can be different for each device)

WARNING!!! Old coefficients are lost as soon as new coefficients are written in to FLASH memory.

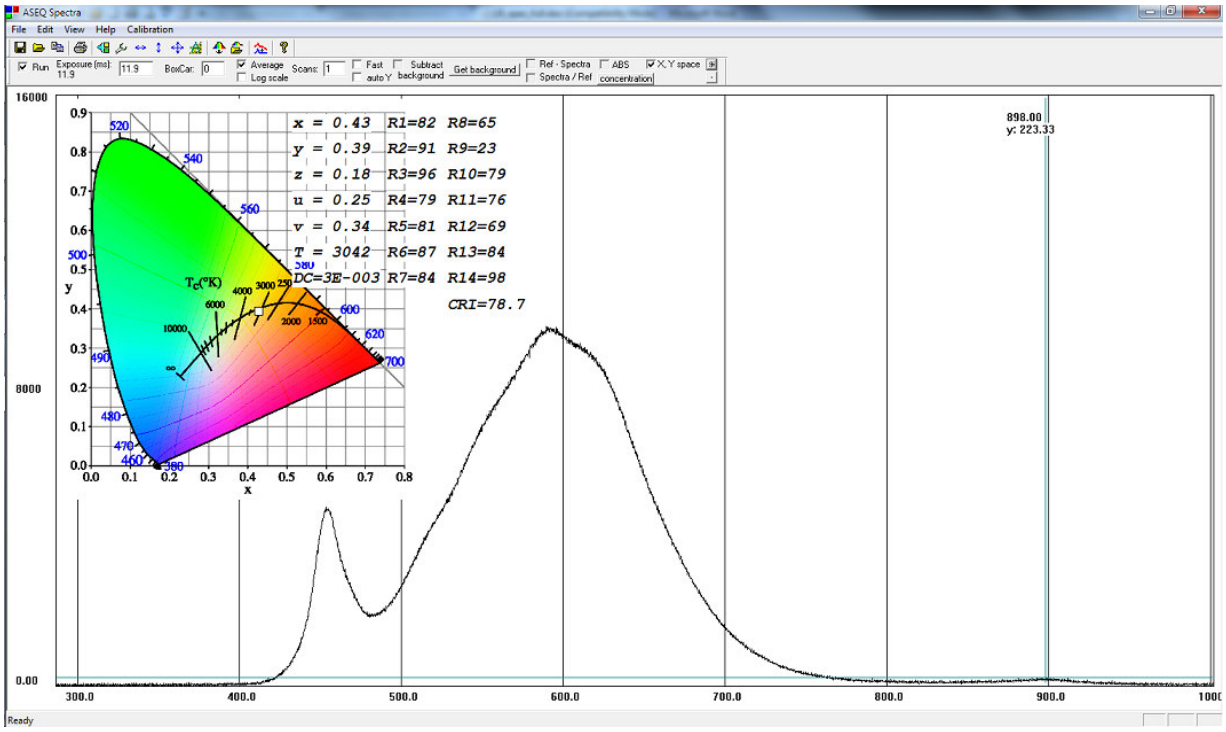
"XYZ Planck calibration" see "Planck calibration" paragraph
"Plastic calibration (Raman only)" - option necessary for Raman spectrometers only.

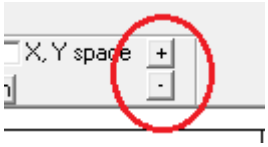
CRI calculation on XYZ color space

Spectrometer can be calibrated to measure CRI (x, y, z, u, v, Temperature, DC, R1..R14 and CRI parameters) on XYZ color space. “X,Y space” option is available 

if spectrometer has calibration for this function.

It is recommended to set “BoxCar” parameter equal to 10. CIE 1931 chromaticity diagram appears in the window of the ASEQ Spectra program with calculated x, y, z, u, v, Temperature, DC, R1..R14 and CRI parameters.



“+” and “-” buttons: 

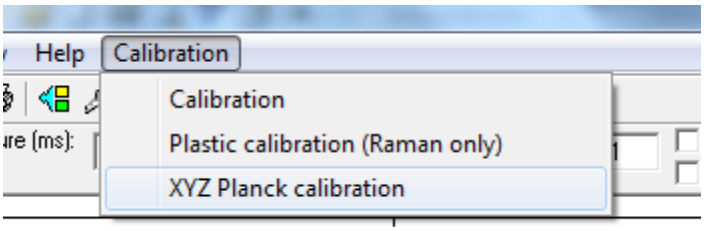
increase or decrease size of XYZ diagram and font size of calculated x,y,z coordinates.

Planck calibration

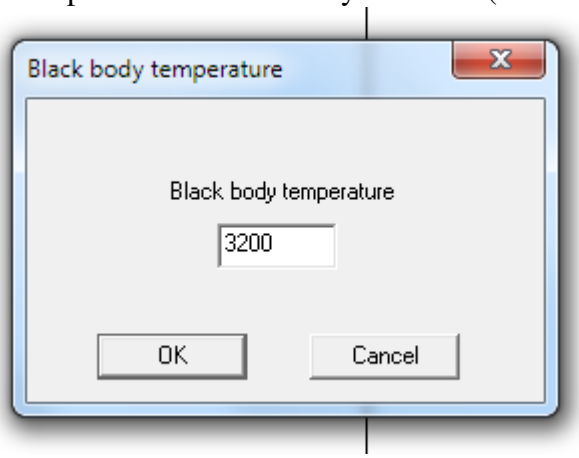
It is possible to make spectrometer sensitivity calibration. It is necessary to obtain spectra of black body with known temperature.
Following steps should be done to make sensitivity calibration:

1. Run spectra acquisition
2. Switch on black body radiation with known temperature
3. Point spectrometer (with cosine corrected adapter) or fiber with adapter to reference light source
4. Adjust exposure time to have optimal Signal to Noise (it is recommended to keep signal intensity around 10000 counts at low exposure time)

5. Close light input optical port to collect background
6. Click “Get background” (it is recommended to increase averaging, Scans = 10)
7. After background is collected mark “subtract background”
8. Point spectrometer (with cosine corrected adapter) or fiber with adapter to reference light source
9. Click “Calibration” -> “XYZ Planck calibration”.



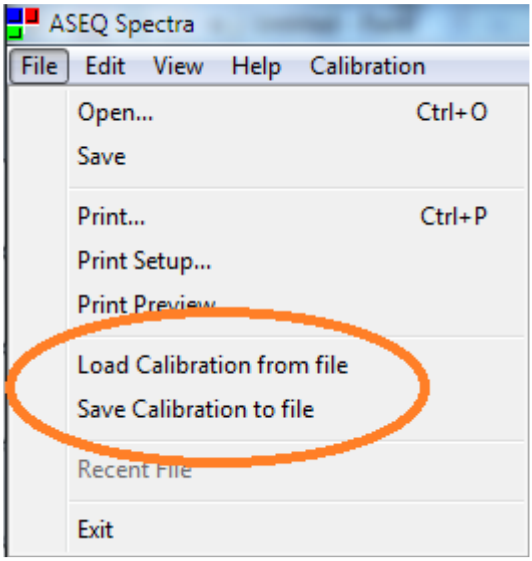
10. Set temperature of black body radiation (Kelvins) and click OK:



11. Calibration is done.

Saving loading calibration from file

User can save current calibration and load calibration from file

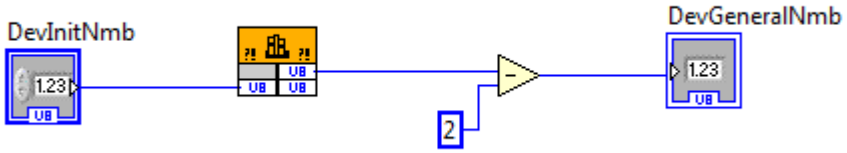


LabView software (included in standard configuration)

Save included “adcDLL_xxxx.dll” file in the directory you want.
After first run of the subVI LabView will try to find location of “adcDLL_xxxx.dll” file and will ask user to specify it. Specify path to the “adcDLL_xxxx.dll” file. Initially it sets to C:\CLR1\adcDLL_xxxx.dll. It is not necessary to specify path to the “adcDLL_xxxx.dll” file if this file is saved in the “C:\CRL1” directory.

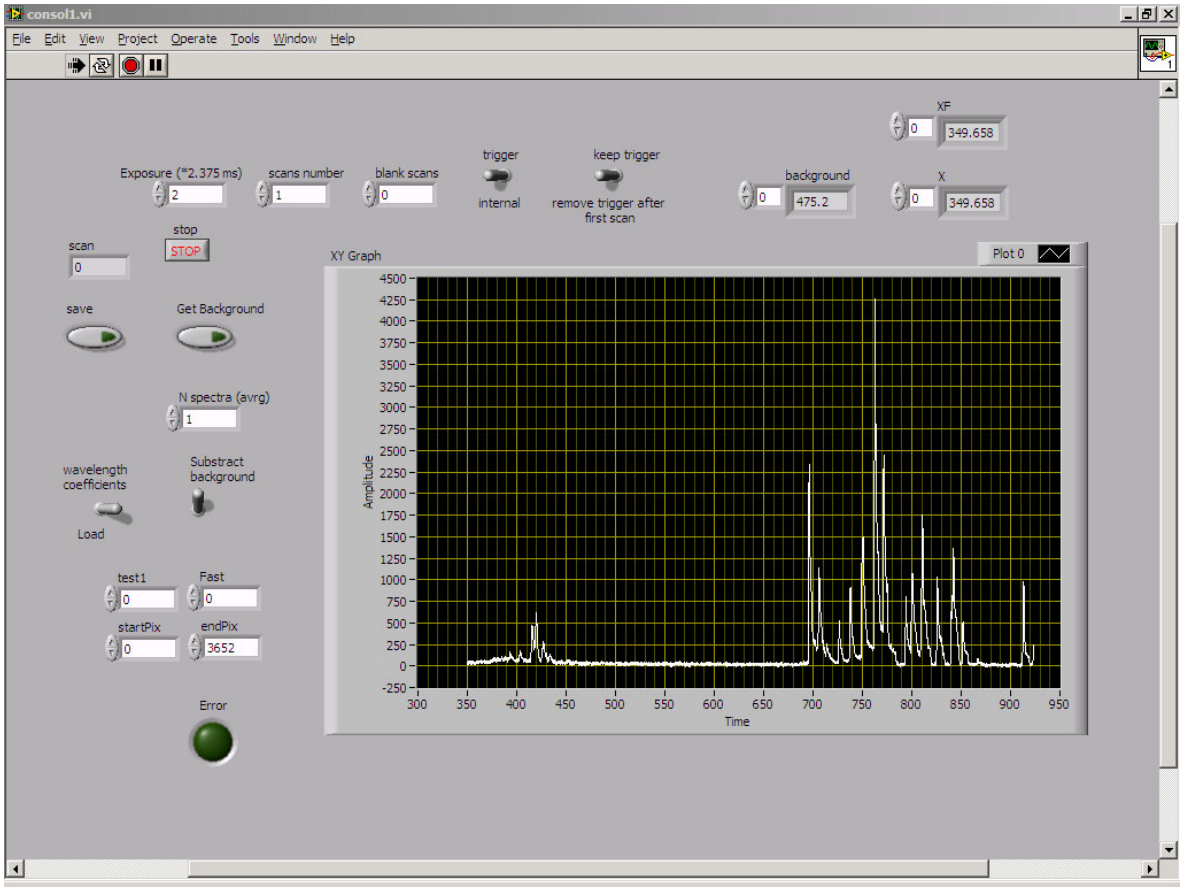
Several spectrometers can be connected to the same computer

Device_List_and_Init.vi

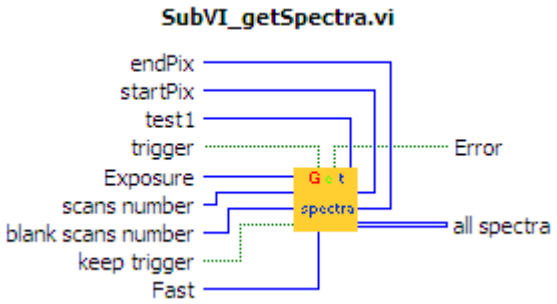


DevInitNmb – If set to 0, Device_List_and_Init will return number of spectrometers connected to the computer. Otherwise should be set equal to the spectrometer number you want to initialize

Main program:



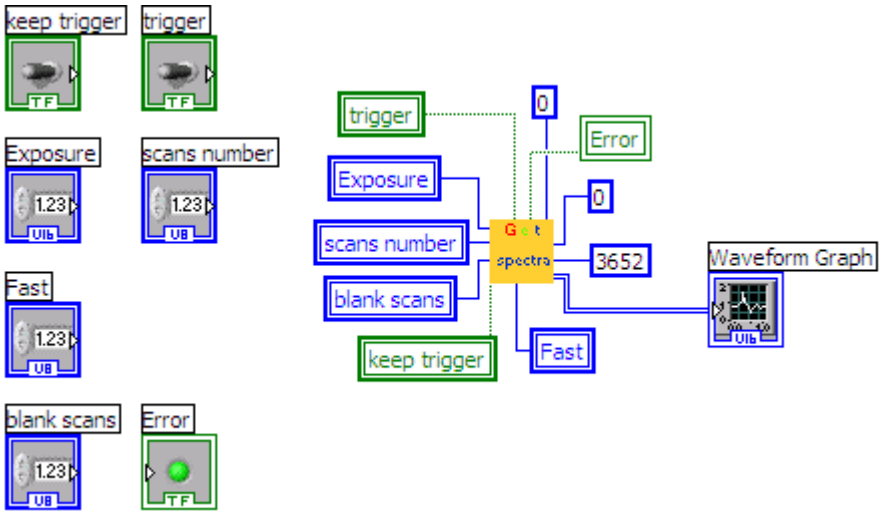
Get Spectra subVI



Parameters can be changed:
"Exposure" – exposure time. Equals to Exposure of the device in millisecond divided by 2.375 ms.
"scans number" – number of data collections (see "Trigger options" section);
"blanc scans number" – number of blanc scans between each data collection (see "Trigger options" section);
"trigger" – use trigger option (see "Trigger options" section);
"keep trigger" – if false data is acquired after external trigger (mode b), see "Trigger options" section). If true every spectra is collected after external trigger (mode c), see "Trigger options" section). Parameter is valid if parameter "trigger" = true.
"Fast" – increase speed of spectral data transfer if 1. It causes transfer one out of every two consecutive spectral data points. If 0 – normal mode.

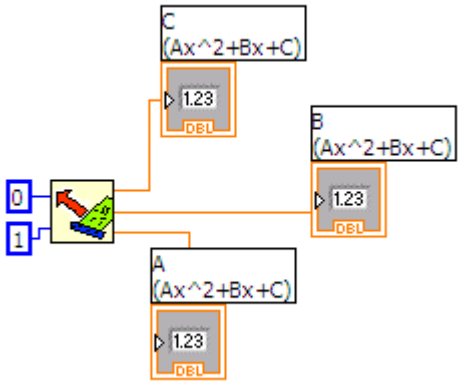
Parameters should be kept as it set by default:
"endPix" equal to 3652,
"StartPix" equal to 0,
"test1" equal to 0.

Typical diagram to acquire and read specified number of spectra in specified regime:

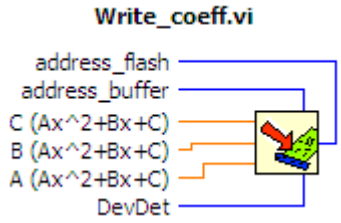


Read Calibration coefficients

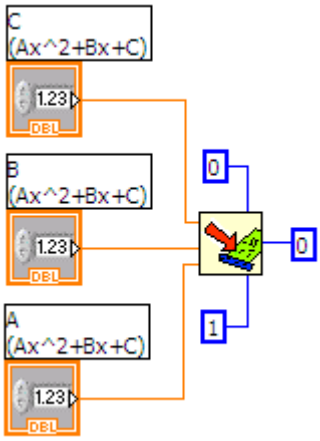
Keep parameter “address” equal to 0 and “DevDet” equal to 1.
Typical diagram to read calibration coefficients A, B, C (wavelength = Ax^2+Bx+C, where x – CCD pixel):



Write Calibration coefficients



Keep parameter “address_flash” and “address_buffer” equal to 0 and “DevDet” equal to 1.
Typical diagram to write calibration coefficients A, B, C (wavelength = Ax^2+Bx+C, where x – CCD pixel):



WARNING!!! Old coefficients are lost as soon as new coefficients have been written in to FLASH memory.

XYZ coordinate calculation on XYZ color space

Spectrometer can be calibrated to measure xyz coordinates on XYZ color space. “show_color_xyz_from_loaded spectra.vi” loads calibration information from spectrometer FLASH memory and asks user to load saved spectra (format: the same as spectra saved by “consol_0001_norm_Flash2.vi”). “show_color_xyz_from_loaded spectra.vi” calculates x,y,z coordinates based on loaded information.

VC++ software (included in standard configuration)

adcDLL1.dll description

1. void DevDetect(unsigned char *DvDetect);

Check device.

If *DvDetect = 0 – device is not initialized

If *DvDetect = 1 – device is not initialized

2. unsigned char* ReadAndWriteToDevice(unsigned char *InputReport1, unsigned char*OutputReport1, int DevDet);

General purpose command. Is used to set acquisition parameters, start exposure, write and read from Flash memory.

unsigned char *InputReport1 – 64 bytes array;

unsigned char* OutputReport1 – 64 bytes array with command to be written to device;

int DevDet – if 1 – make device initialization; if 0 – do not make device initialization (should be 0 if device was initialized already).

3. unsigned char* ReadAndWriteToDevice_new(unsigned char *InputReport1, unsigned char *OutputReport1, int DevDet)

General purpose command. Is used to set acquisition parameters, start exposure, write and read from Flash memory.

unsigned char *InputReport1 – 64 bytes array;

unsigned char* OutputReport1 – 64 bytes array with command to be written to device;

int DevDet – if 1 – make device initialization; if 0 – do not make device initialization (should be 0 if device was initialized already).

4. unsigned char Device_List_and_Init(unsigned char DevInitNmb)

DevInitNmb – If set to 0, Device_List_and_Init will return number of spectrometers connected to the computer. Otherwise should be set equal to the spectrometer number you want to initialize

5. int GetSpectra(unsigned __int16 *InputSpec1, unsigned char SpecNmb, unsigned __int16 startPix, unsigned __int16 endPix, unsigned char Fast, unsigned char test1, unsigned __int16 tot_startPix, unsigned __int16 tot_endPix)

Command to read acquired data.

“*InputSpec1” = 3653 elements (unsigned __int16) array,

“SpecNmb” = 1,

“endPix” = 3652,

“StartPix” = 0,

“Fast” = 0 or 1,

“test1” = 0.

“tot_startPix “ = 33

“tot_endPix” = 3685

Set acquisition parameters, start exposure and read spectra from device

Following steps should be made:

1. Set parameters and start acquisition. Send command *ReadAndWriteToDevice* with following parameters:

OutputReport1:

byte 1 = 1

byte 2 = low 8 bits of “Exposure time” (unsigned __int16) (exposure time (ms) = 2.375 (ms)* “Exposure time” (unsigned __int16))

byte 3 = “scans number” (char)

byte 4 = “blank scans number” (char)

byte 5 = 1

byte 6 = “use trigger” (bool) + 2*“keep trigger” (bool)

byte 7 = high 8 bits of “Exposure time” (unsigned __int16)

2. wait 2.375 (ms)* “Exposure time” (unsigned __int16)

3. Check acquisition status. Send command *ReadAndWriteToDevice* with following parameters:

OutputReport1:

byte 1 = 2

Return data (unsigned char *InputReport1):

Byte 3: if “1” – acquisition in progress, if “0” - acquisition is complete and data is ready to be transferred to computer.

4. Reset address. Send command *ReadAndWriteToDevice* with following parameters:

OutputReport1:

byte 1 = 3

5. Read one acquired spectra from device. Realize *GetSpectra* with following parameters:

“*InputSpec1” = 3653 elements (unsigned __int16) array (spectral data are written to this array),

“SpecNmb” = 1,

“endPix” = 3652,

“StartPix” = 0,

“Fast” = 0 or 1,

“test1” = 0.

“tot_startPix “ = 33

“tot_endPix” = 3685

6. Realize this point if “scans number” > 1. Send command *ReadAndWriteToDevice* with following parameters:

OutputReport1:

byte 1 = 9

byte 2 = 0x01

byte 3 = 0x80

7. Repeat 5 and 6 “scans number” times

8. Repeat 4

Read flash memory

“read_bytes” – bytes to read at “address” (3 bytes),

“Reading cycles” = (int)(“read_bytes” / 64)+1, j – current cycle number (j=0.. “Reading cycles”-1)

“current address” = “address” + j*64;

Make following steps “Reading cycles” times (where j – current cycle number):

1. Send command *ReadAndWriteToDevice_new* with following parameters:

OutputReport1:

byte 1 = 161,

byte 2 = 3rd (high) byte of the “current address”,

byte 3 = 2nd byte of the “current address”,

byte 4 = 1st (low) byte of the “current address”,

Return data (unsigned char *InputReport1):

64 bytes from flash memory starting from address “current address”.

Read calibration coefficients

Wavelength vs. CCD pixel calibration is perform via 2nd order polynomial approximation (Ax^2+Ax+C, where x – CCD pixel).

Baseline subtraction coefficients : a and b;

Calibration coefficients are written in Flash memory in ASCII format.

Read 80 bytes starting from address = 0;

0 – 15 bytes represent coefficient A

16 – 31 bytes represent coefficient B

32 – 47 bytes represent coefficient C

48 – 63 bytes represent coefficient a

64 – 79 bytes represent coefficient b

Read correction spectra

Read 7306 bytes starting from address = 4096.

i=1..7306 bytes contain 3653 two-bytes data points. i=2*n-1 low byte, i=2*i – high byte, where n=1..3653.

“correction spectra” = “3653 two-bytes data points” / 32768;

Spectra obtained from spectrometer should be calculated according to following instruction:

(“*InputSpec1” – a*“Exposure time” + b) / “correction spectra” + ; a*“Exposure time” + b;

General Dimensions

(millimeters [inches])