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Colorimetric system based on CCD array spectrometer

Boban Zarkov[1], Kolja Bugarski[2]

[1]*Directorate of Measures and Precious Metals (DMDM), Serbia*

[2] *University of Belgrade School of Electrical Engineering, Belgrade, Serbia*

e-mail: zarkov@dmdm.rs

INTRODUCTION

For the needs of the new realization scale of luminous intensity through radiometric detectors in the laboratory for optical quantities of the Metrological Institute of the Republic of Serbia, a measuring colorimetric system was developed to determine chromatic coordinates and correlation color temperature - CCT of light sources.

METHODS

The system is based on a spectrometer with a toroidal grating manufactured by Ocean Optics, model Torus, slit width 25µm, which contains a Sony ILX511B linear CCD-array detector with a resolution of 0.265nm. The receiving optical part consists of fiber 400µm, length 2m and integration sphere with a diameter of 38.1 mm. Application Software is written in virtual instruments - VI Labview environment. The spectral responsivity of the spectrometer was performed on the primary spectrophotometric system by the method of comparison with standard radiometric silicon detectors with an extended uncertainty of 0.6% for (k = 2). Wavelength accuracy of spectrometer was checked via arc lamps with maximum deviation of 0.2nm .
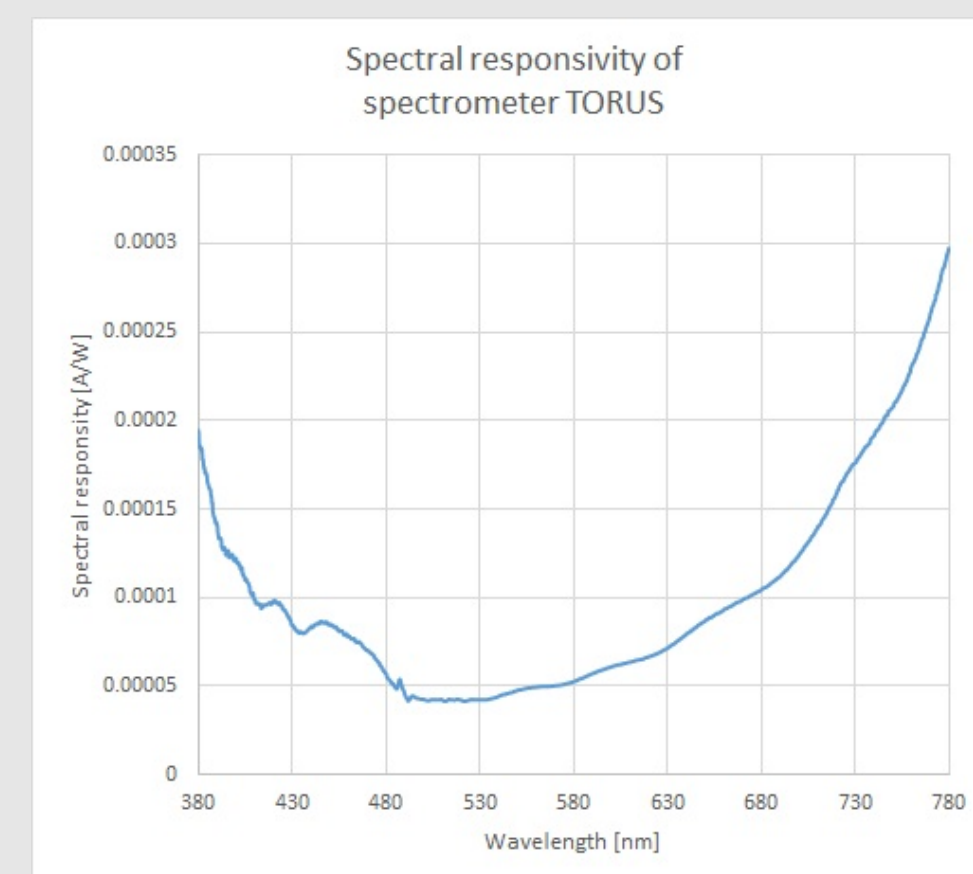

Torus spectrometer
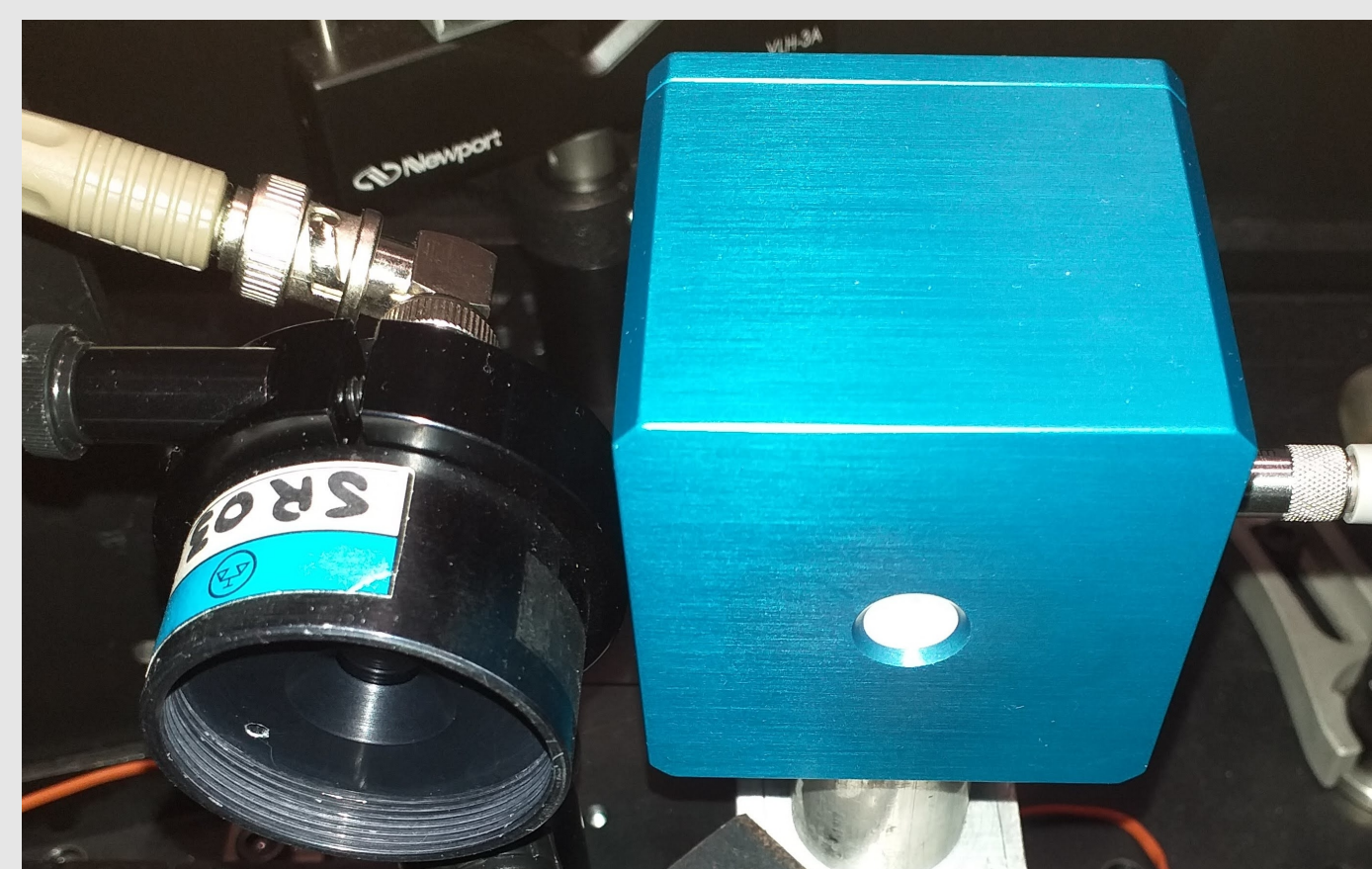

Spectral responsivity transfer
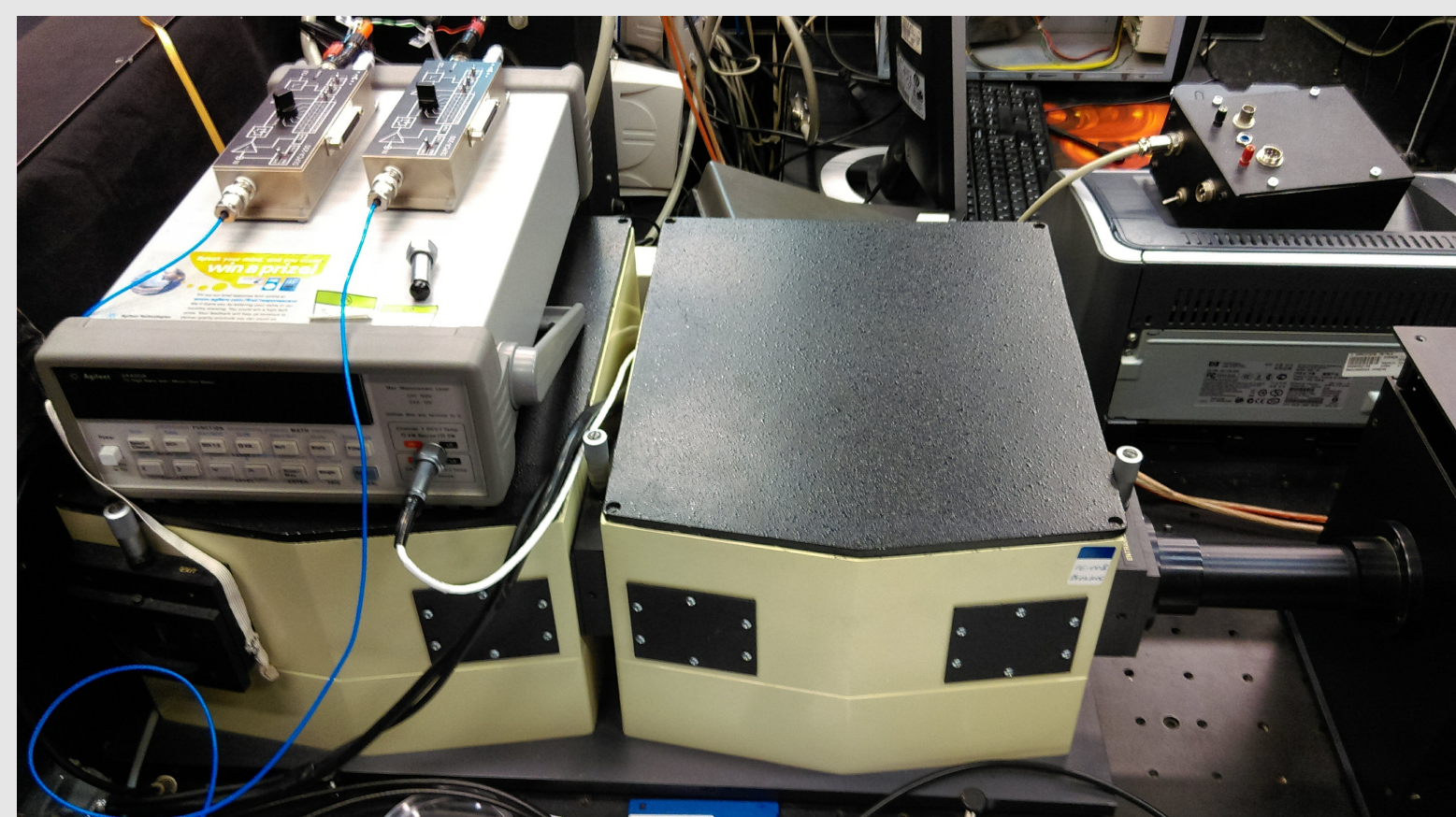
Primary spectrophotometric system in DMDM

Spectral responsivity of Torus

The VI Chromaticity 2021.vi program acquires data from the spectrometer via the USB bus and executes certain mathematical operations and calculations. The main form of the program shows the intensity of the source as a function of wavelength, the normalized spectral power distribution – SPD of the light source, the values of the calculated chromatic coordinates for the standard CIE observer 1931 as well as the CCT value shown on the chromatic diagram. The user also has the ability to visually compare normalized SPD curves for the measured light source and blackbody at the same temperature. Additional advanced features of the colorimetric system enable compensation of dark current, possibility of adjusting spectrometer parameters in real time, recording of obtained values and graphics in a file as well as recording of spectral transmittance of optical filters and their determination of chromatic coordinates.
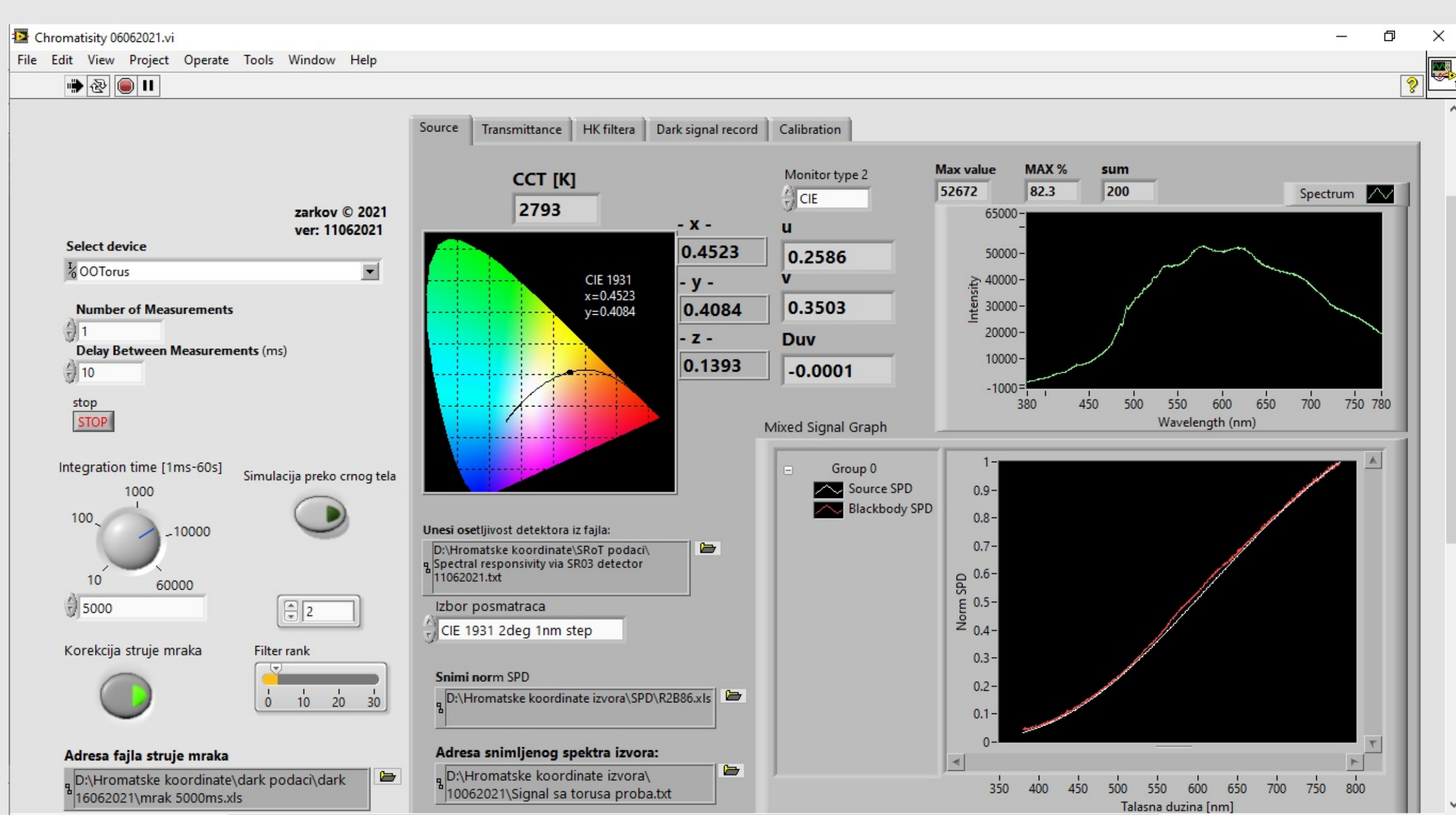

Main form of Chromatisity.vi - colorimetry software

RESULTS

The system was validated with three bulbs at different color temperatures (2800K, 2856K and 2965K) where is maximum measured deviation was 3K. The intensity - integration time curve was recorded where it was shown that there is a nonlinearity above 75% of the maximum intensity value. A significant influence of temperature change during measurement on measurement results was noticed, which we managed to limit by temperature stabilization of the spectrometer in the temperature interval of ± 0.2 ^{0}C
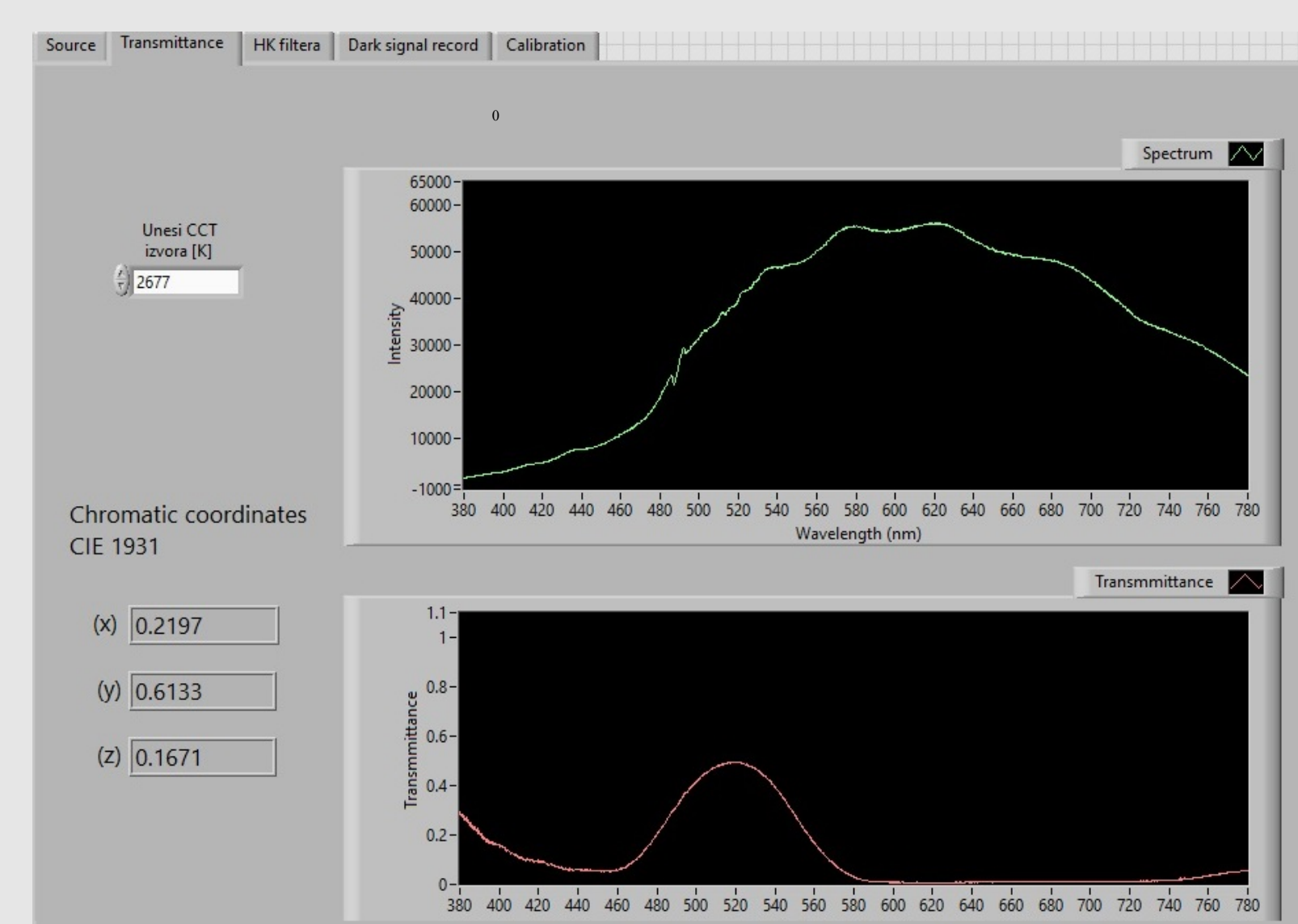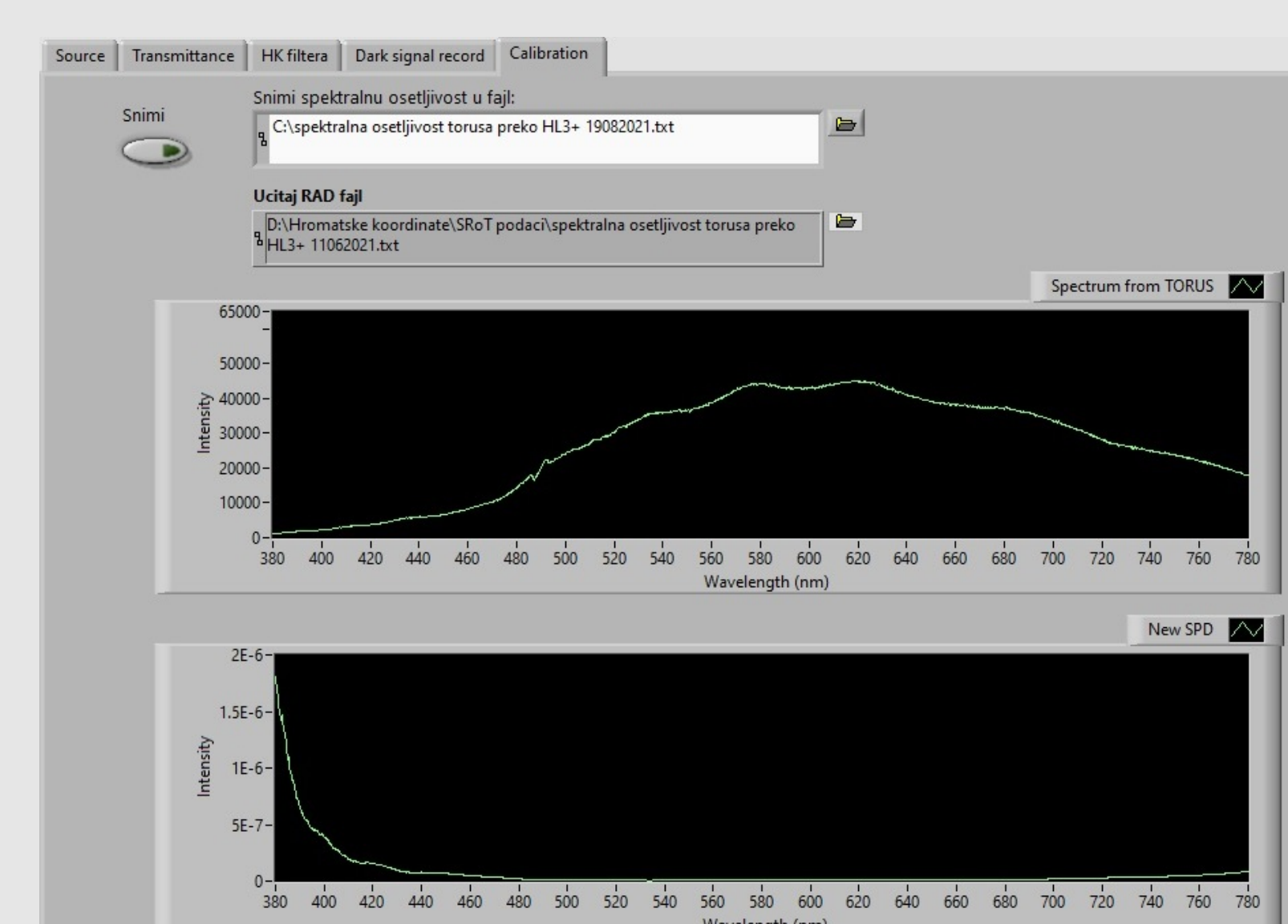

Transmittance of transparent filter
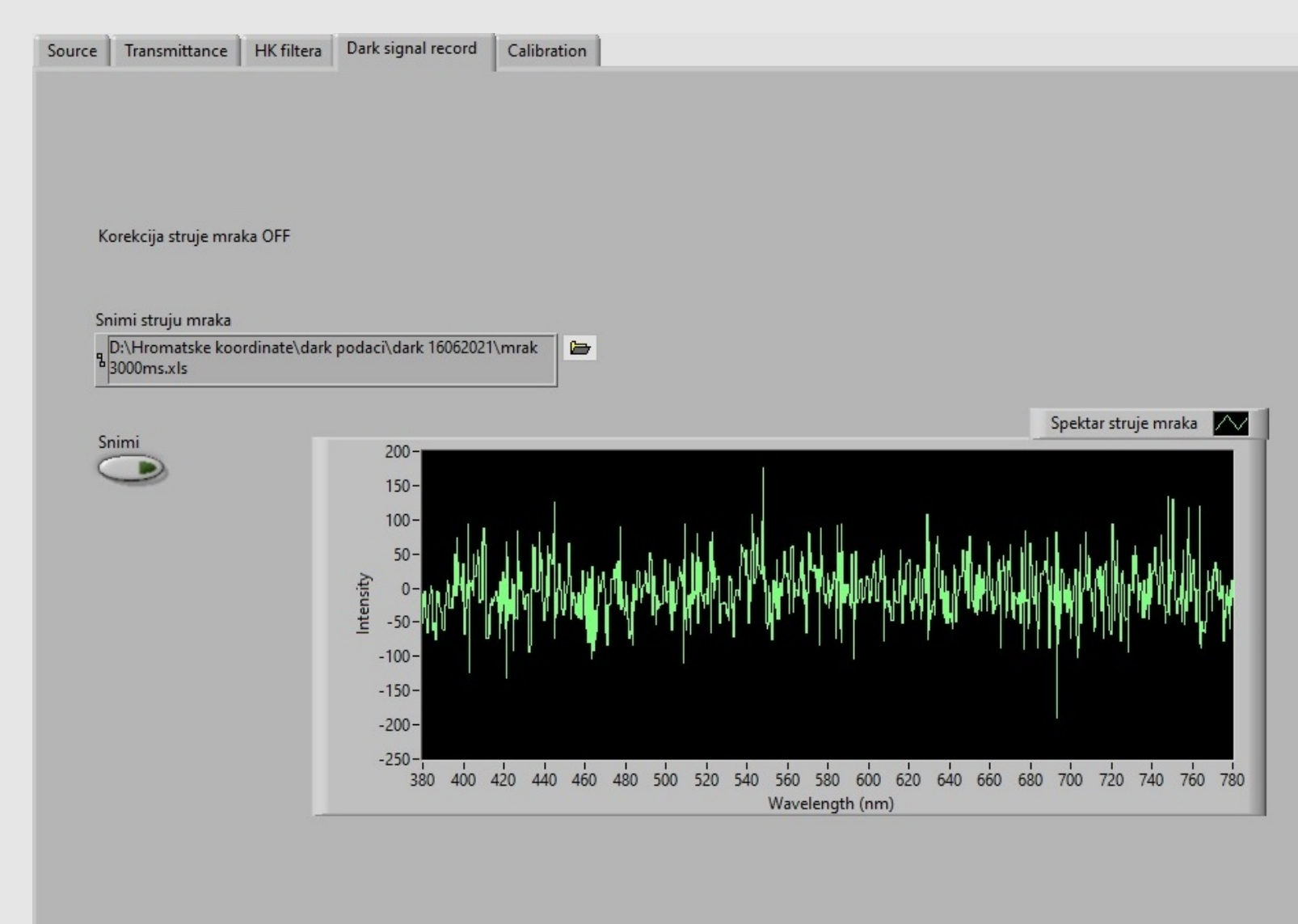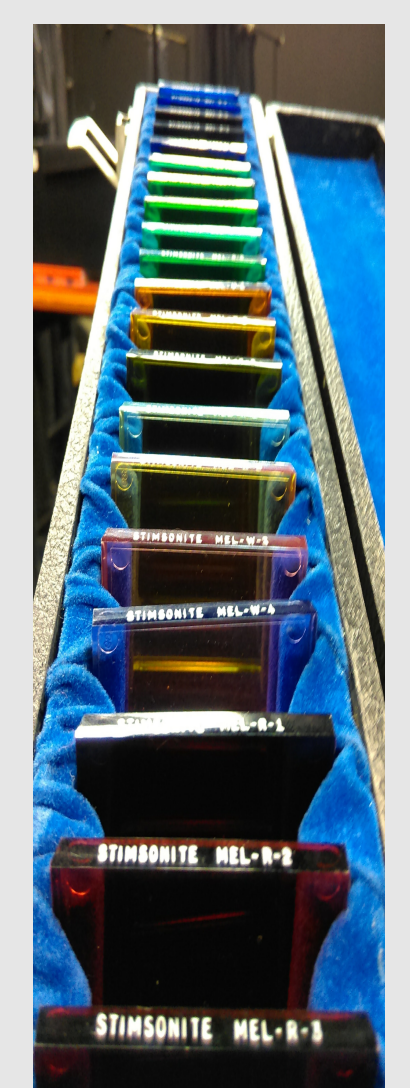
Dark signal record
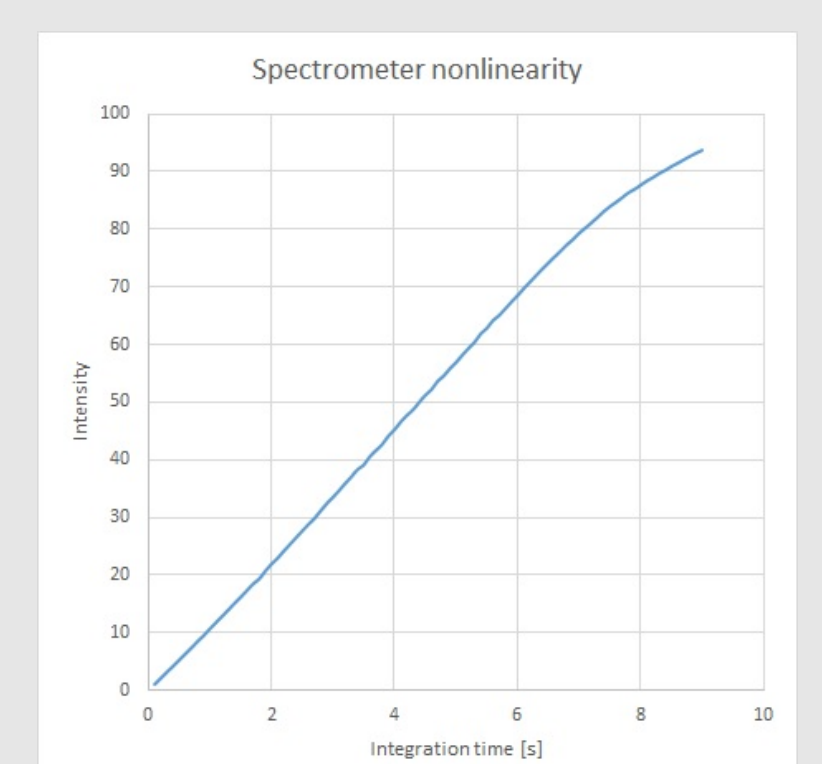
Spectrometer nonlinearity

Calibration of spectrometr with irradiance lamp

CONCLUSION

In the laboratory for optical quantities of the Metrological Institute of the Republic of Serbia, a measurement colorimetric system was developed to determine the chromatic coordinates of light sources, transparent filters and reflective plates as well as correlation color values of light sources with measurement uncertainty of 10K (k = 2). Based on this system, which performs real-time measurements, we are able to correct the deflection of the lamp from CCT = 2856K during the new realization of the light intensity scale (candela) via a radiometric detector.

Bulb designation	Reference value CCT [K]	Measured value CCT [K]	Deviation CCT [K]	Measurement uncertainty [K]	Traceability
#47	2792K	2971K	-1	10	PTB
A595	2856K	2856K	0	10	NPL
R2B86	2965K	2968K	3	10	LNE

REFERENCE

[1] Münevver Nehir, Carsten Frank, Ste en Aßmann, Sensors, 19 (12, Article 2833)

[2] Boban Zarkov, Slavica Simic, Optical and Quantum electronics (2018), vol.50(8)