# Application of the LMK color with the LMK LabSoft program for measuring Blue light hazard (BLH)

## Preamble

### Requirements for the LMK configuration

For measuring blue light hazard, the filter wheel of the LMK color has to be equipped with a filter glass that is adapted to the sensitivity function for the blue light hazard (see Figure 1). The measurement result when using the BLH filter glass is calibrated to the absolute BLH weighted radiation [W / sr * m²]. When you use this filter glass to take a measurement image, the information provided in the measurement image is linked to the BLH weighted radiance $L_{e\,(BLH)}$ ($\lambda$).
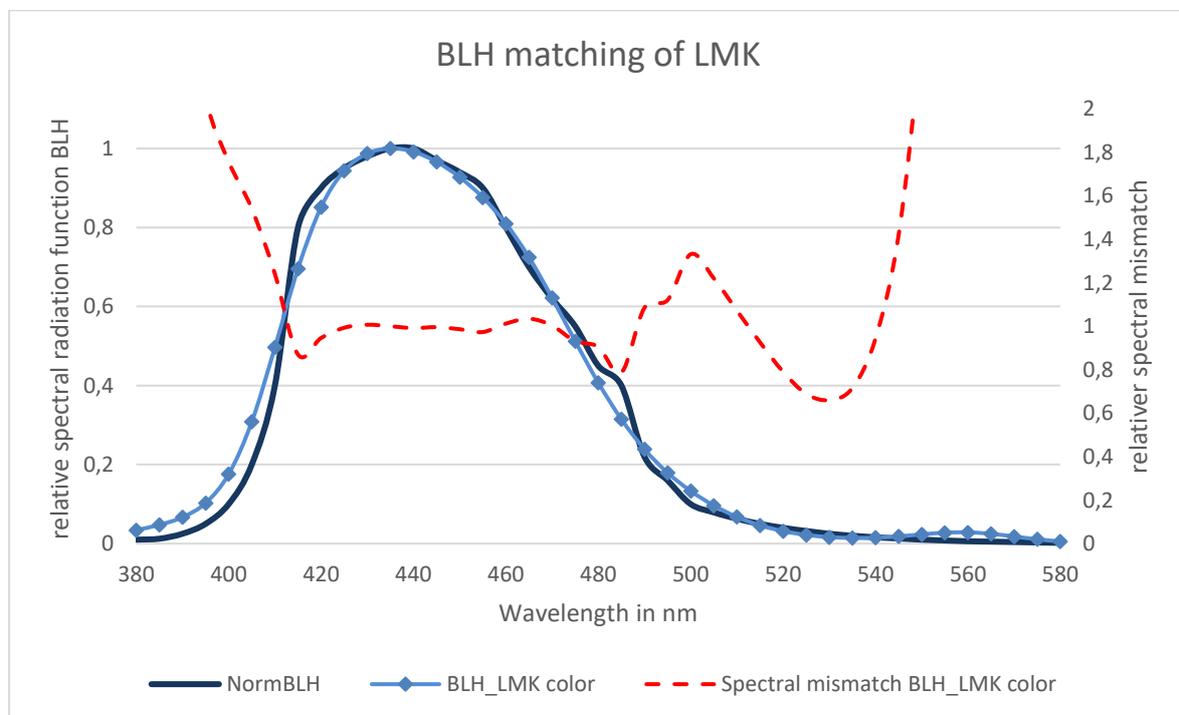


Figure 1 Display of the spectral BLH adaptation of a typical LMK

### Motivation EN 62471

The EN 62471 standard deals with the photobiological safety of lamps and lighting systems. It specifies limit values for various effects on the eye. Among others, the blue light hazard (BLH) of the human eye. Compliance with these limits and threshold values can be monitored by measurements.

The measurements with the LMK are based on the determination of the weighted radiance $L_{e(BLH)}$ ($\lambda$) by spectral filtering with a full glass filter (see Figure 1).

Depending on the standardized sorting into risk groups, certain measurement angles or aperture angles must be used: 100 mrad (5.73 °); 11 mrad (0.63 °) or 1.7 mrad (approx. 0.1 °) (see Figure 2).

The first step in using the LMK is the analysis of radiance in the image (ILMD Type I). Furthermore, not only the radiance but also the geometric position information about its origin is relevant and necessary to extract information for this application (ILMD Type II).
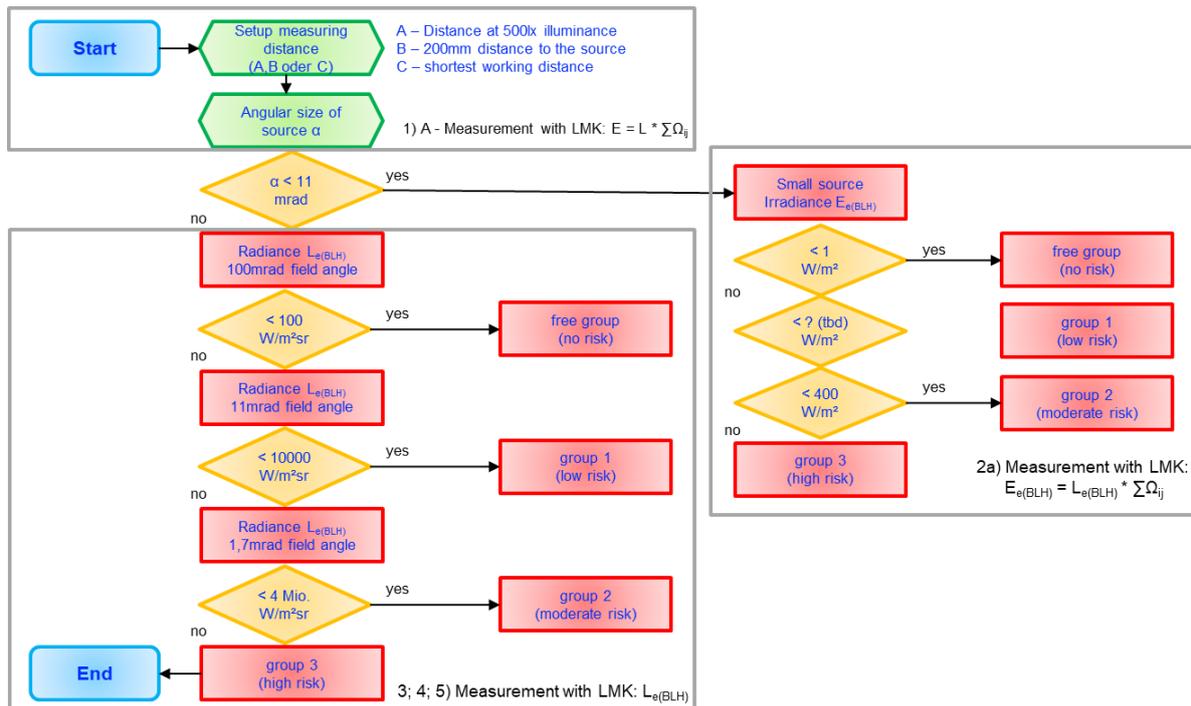


Figure 2 Overview of the standardized sorting into risk groups of EN 62471

## Measuring procedure of EN 62471

1. Selection of the measuring distance:
   a) For products of general lighting: Determination of the distance from the source at which it generates an illuminance of 500 lx
   b) All other applications: Use 200mm as measuring distance – (if necessary, a different distance must also be set depending on the application)

2. Determination of the angular expansion α of the source
   a) if α <11 mrad, a small source is assumed and the irradiance $E_{BLH}$ is measured

3. Measurement of the radiance $L_{(BLH)}$ with a measuring field angle of 100 mrad (regardless of the actual angular extent of the source)
   a) Classification in the free group if $S_{BLH} < 100$ W / (sr * m²) → End of procedure

4. Measurement of the weighted radiance with a measuring field angle of 11 mrad
   a) Classification in risk class 1 if $S_{BLH} < 10e4$ W / (sr * m²) → End of procedure

5. Measurement of the weighted radiance with a measuring field angle of 1.7 mrad
   a) Classification in risk class 2 if $S_{BLH} < 4 \cdot 10e6$ W / (sr * m²) → End of procedure
   b) Classification in risk class 3 if $S_{BLH} > 4 \cdot 10e6$ W / (sr * m²) → End of procedure

# Measuring the BLH using the LMK LabSoft program and additional software package

Technoteam offers a software add-on for the LMK Labsoft to support the evaluation of the blue light hazard according to the measuring method described above. This works based on the already mentioned integrated BLH filter glass. With the help of this add-on, the weighted radiance Le BLH($\lambda$) of recorded light sources can be determined in LMK measurement images (see Figure 3).

The add-on for the LMK LabSoft program requires the standard version of the software. It is part of the delivered content of the LMK system - if the BLH adapted filter glass is available for the internal filter wheel of LMK color. It is also available as a free download on the TechnoTeam software download server. Once the LMK LabSoft program package is installed, the add-on can be installed additionally with the supplied file. After installation, it is available via the LMK LabSoft main menu "Macro | Blue light hazard (BLH)".

## Start and operation of the BLH add-on

Before starting the add-on, the LMK that is used for capturing the BLH weighted image must be initialized in the LMK LabSoft program. When starting the addon, the availability of a connected LMK color and the BLH color filter glass is checked. Otherwise the start is aborted and a note about missing LMK calibration data is displayed. Once the addon had started the following dialog will appear:
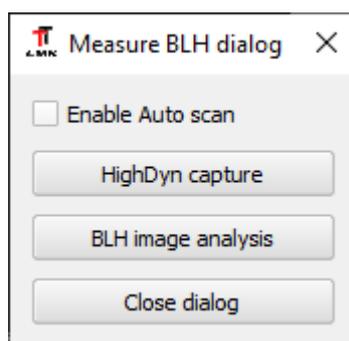


Figure 3 Dialog of the BLH add-on

At the same time, the add-on program creates an additional image "BLH image" used for the image capture. The measured quantity and unit of this BLH image is the radiance $L_{e(BLH)}$ in [W / sr * m²]. Since the blue light hazard measurement procedure works based on measurement angles, the image is set with a polar aligned coordinate system. This angular coordinate system shows the geometrical calibration data of the initialized lens. In addition, the add-on sets the position of the color filter wheel of the LMK color to the BLH filter glass position.

## Overview of the dialog elements

1. "Enable Auto scan" – This option allows the add-on to conduct an auto scan before the BLH weighted measurement image is taken. If a modulation frequency has been set via the exposure time dialog, this will also be considered in the auto scan option. This option is recommended when the light output of the test sample (light source) is unstable or changes, and the exposure time must be adjusted shortly before the capture of the image.
2. "HighDyn capture" - With this button, the LMK LabSoft program performs a monochrome high dynamic image capture using the BLH filter glass. For this type of image capture, the program setting and the last entered exposure time values are used as starting value.

3. "BLH image analysis" - This button is used to analyze the BLH image with a dedicated statistical parameter set to evaluate the relevant information for the classification of the test sample according to EN 62471. Further details are explained in the following section.

4. "Close dialog" – With this button the dialog is closed and the addon is terminated. When exiting, the color filter wheel is reset to the photopic color filter glass V(λ). All previously measured data (images, tables) remain available in the LMK LabSoft program for further analysis.

*Note: During startup process the add-on also checks the availability of existing BLH analysis data in the running LMK LabSoft program session. This data is further used and possibly overwritten if the "HighDyn capture" or the "BLH image analysis" buttons are used.*

# BLH data analysis according to EN 62471

For the complete assessment of photo-biological safety, the following measurement parameters are necessary:

1. Irradiance $E_{BLH}$
2. Radiance $S_{BLH}$
3. Extension $\alpha$ (angular size)

According to the standard, all measured blue light hazard values must be given at a distance of 200mm, unless the product in question are for general lighting – in which case the measurements would have to be taken at a distance that would result in an illuminance of 500lx. As a rule, all permanently installed lighting systems such as street and building lighting, stadium lighting systems or stage lights are counted as general lighting. For portable light sources such as flashlights, vehicle headlights or headlamps, the 200mm rule applies.

*Note: The delivered software supports the BLH data evaluation under the condition of a correctly set measuring distance in advance, as described in the first section "Measuring procedure – EN62471". In other words – it supports the measuring procedure described in EN62471 only from the second step on.*

## "BLH image analysis" - BLH data retrieval with the add-on program

Once the "BLH image analysis" is pressed, the add-on program will conduct an image processing and a statistical analysis to retrieve the necessary measurement values for the classification into risk groups. Thus, "BLH image" is analyzed and three additional auxiliary images are created. This procedure will take some time, depending on the speed of the system and on the LMK type used (image size). The processing time is displayed in the LMK LabSoft program via the mouse cursor, which is shown as busy.

After processing, the following table is displayed (see Figure 4). All necessary data for classifying the photo-biological safety of a test sample according to the EN62427 is available in this table.

| Stat.No. | Parameter | Image | Region | Class | Area | Min | Max | Mean | Disp | BLH Irradiance (W/m²) | BLH angular size (mrad) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | pix^2 | W/sr*m² | W/sr*m² | W/sr*m² | W/sr*m² | | |
| 1 | Lum_Gr[91] | BLH image 100 mrad | S(BLH) analysis | > 212.75 W/sr*m² | 519900 | 212,8 | 425,5 | 296,9 | 61,31 | 7,053 | 174 |
| 2 | Lum_Gr[92] | BLH image 11 mrad | S(BLH) analysis | > 1203.0 W/sr*m² | 11880 | 1203 | 2406 | 1678 | 318,6 | 0,911 | 26,29 |
| 3 | Lum_Gr[93] | BLH image 1.7 mrad | S(BLH) analysis | > 1528.5 W/sr*m² | 46090 | 1529 | 3057 | 1847 | 300,7 | 3,888 | 51,78 |

Figure 4 Measurement values and evaluation results of the BLH add-on

After the BLH analysis, the table contains all relevant data for the classification of the measured test samples into risk groups according to the standard. The following section explains how the software works in principle.

## Step by step instructions for a BLH analysis – using a test pattern

This section explains the image data analysis, which is started with the button "Evaluate BLH image". The previously recorded "BLH image" is used for this analysis.

***Note: Alternatively, pre-recorded and stored BLH weighted measure images can be loaded. To analyze them and to start the "Measure BLH" add-on, the correct LMK calibration data must also be loaded in the LMK LabSoft program.***
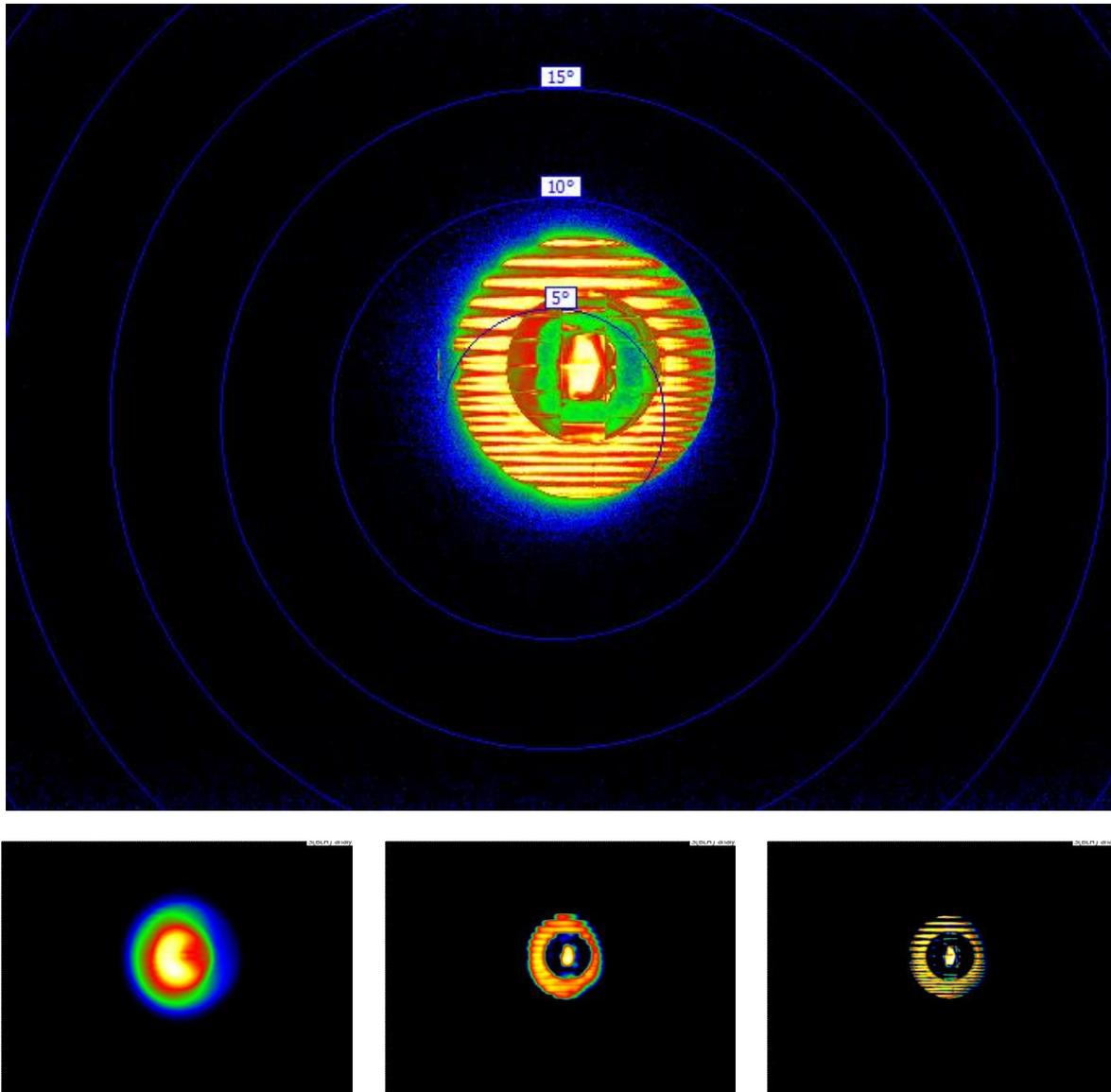


Figure 5 LH filtered/weighted image of a bicycle headlamp(top), averaged images (logarithmic scales) with an aperture of 100mrad (left), 11mrad (middle) and 1.7mrad (right)

In the first step, three additional analysis images are created: "BLH image 100mrad"; "BLH image 11mrad" and "BLH image 1.7mrad". These images are calculated with a blur filter tailored to the respective viewing aperture in mrad.
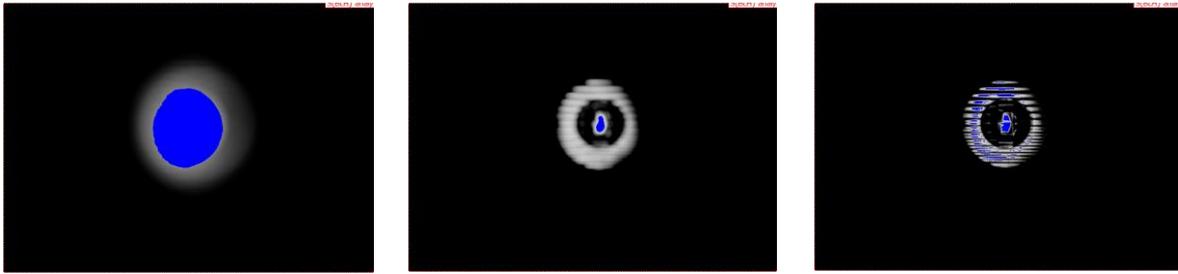
Figure 6 BLH filtered/weighted image with 100mrad (left), 11mrad (middle) and 1.7mrad (right) aperture combined with the display (blue colored) of the 50% emission threshold to determine the size of the active angular area α in mrad.

The second step is to determine the BLH weighted radiance, irradiance and of the angular size of the source using the three recalculated images. For each of the images a specific "luminance object" statistic (see Labsoft operation manual) is created. For each image, a specific threshold value of the BLH radiance is used, which is derived from the classification of the active size of the test pattern relevant for the BLH evaluation. This can be seen in Figure 6. Here the areas that are used for the BLH assessment are marked in blue.

Combining all image pixel classified as source allows the calculation of the "averaged" angular expansion α in mrad of the test pattern. The calculated value is given in the table in the column "BLH angular expansion (mrad)". As an initial value for α > 11 mrad for the measurement procedure of the BLH radiance-based risk group determination, the result of the 3rd line for the image "BLH image 1.7 mrad" must be used (see red marking in Figure 4).

If α < 11mrad, the BLH irradiance of the same image (3$^{rd}$ row) must be used - to determine the risk group in this case. The relevant value can be found in the second-last column – BLH irradiance.

If α > 11mrad, the BLH weighted radiances (column "Mean") for the three analysis images containing different aperture angles can be used to classify the measured test sample into the risk groups according to the EN 62471. For this purpose, this column of the table can be read from top to bottom, starting with the 100 mrad aperture image.