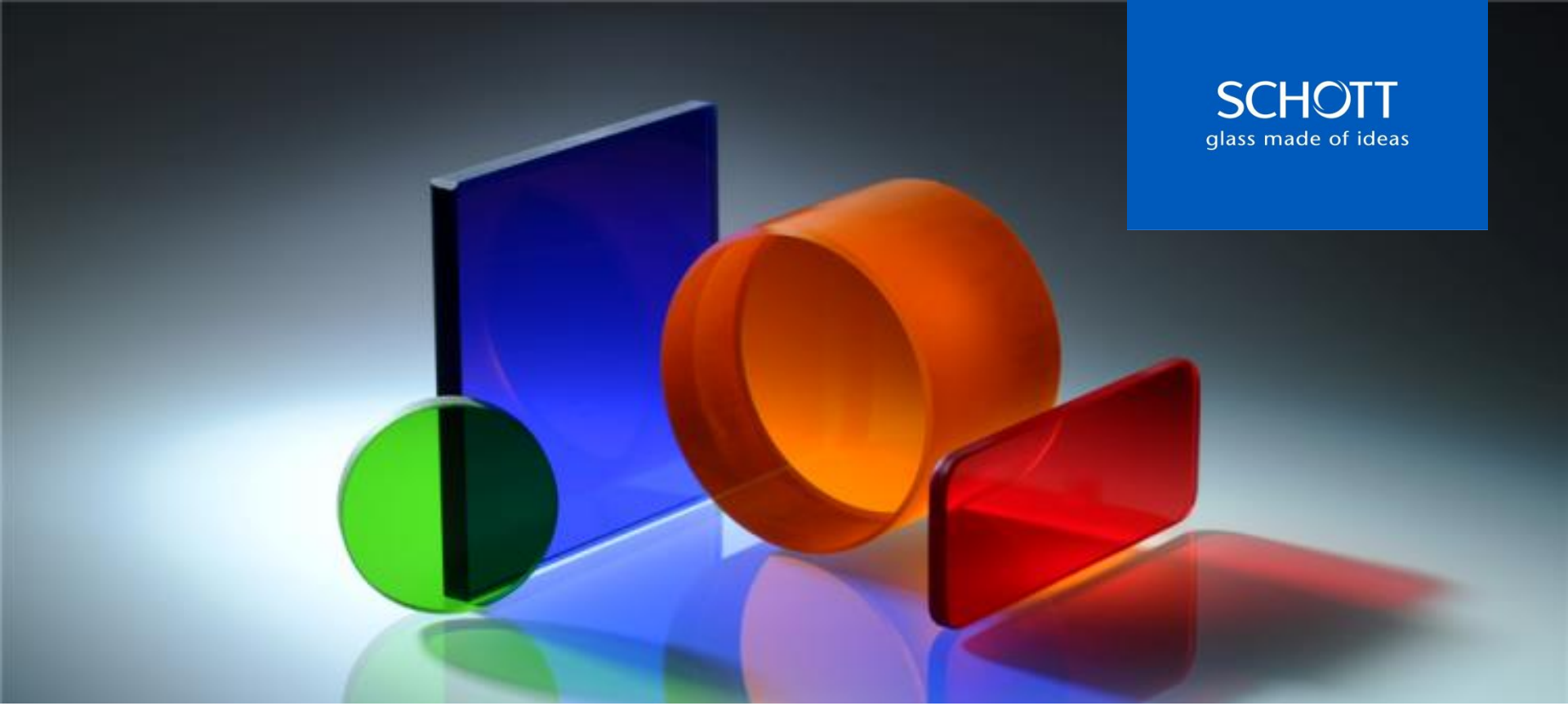

Tutorial on SCHOTT filter calculation tool

2017

Dr. Ralf Biertümpfel, February 2017

Agenda

1. Introduction

2. Properties of a single filter
   - transmittance and internal transmittance
   - optical density and extinction

3. Comparing or Combining filters

4. Color of a filter (combination) and its light source

5. Tabulated data

6. User defined filters and light sources

Intention of the calculation tool

Overview on the functions of the Excel Spreadsheet

- The calculation tool is intended to use for visualizing the optical reference values of our glasses.
  Internal Transmittance, Transmittance, Optical Density and Extinction data can be displayed as a function of wavelength and a desired thickness.
- The internal transmittance data is listed from 200 nm to 5200 nm.
- Some values for the color analysis can be calculated as well.
- The spread sheet offers the possibility to combine and compare several filters in respect to their optical properties.
- The user may add spectral data of filter functions as a target.
- The user may add spectral data for a user defined light source for color analysis.

Functions that are not present

- This tool is not designed for optimizing the design process of an optical system.
- The data base contains only typical transmittance data. There are no tolerances given in this tool.
- This tool was composed with utmost care, however, there is no guarantee on the correctness of algorithms and data.

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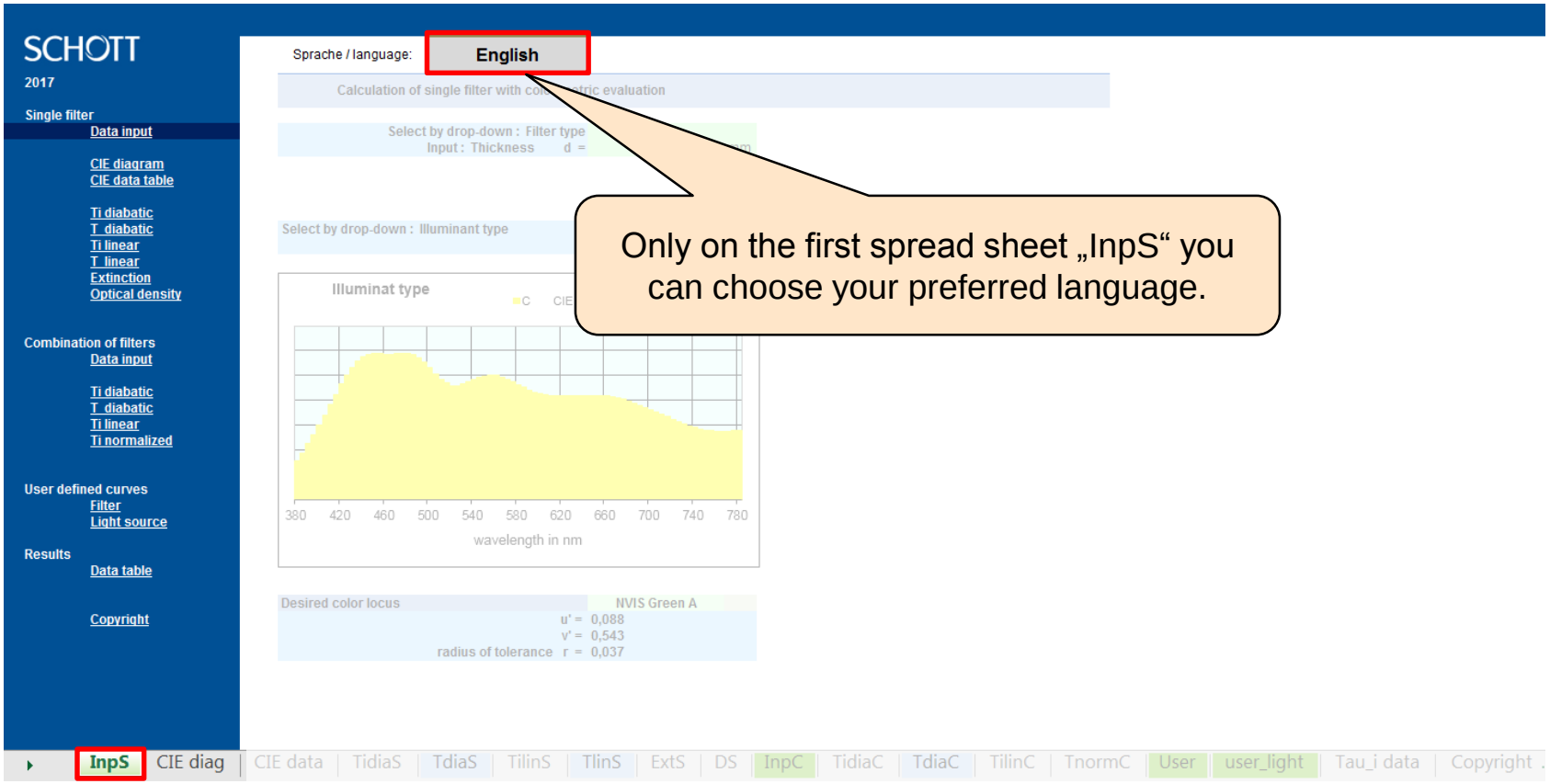
Language



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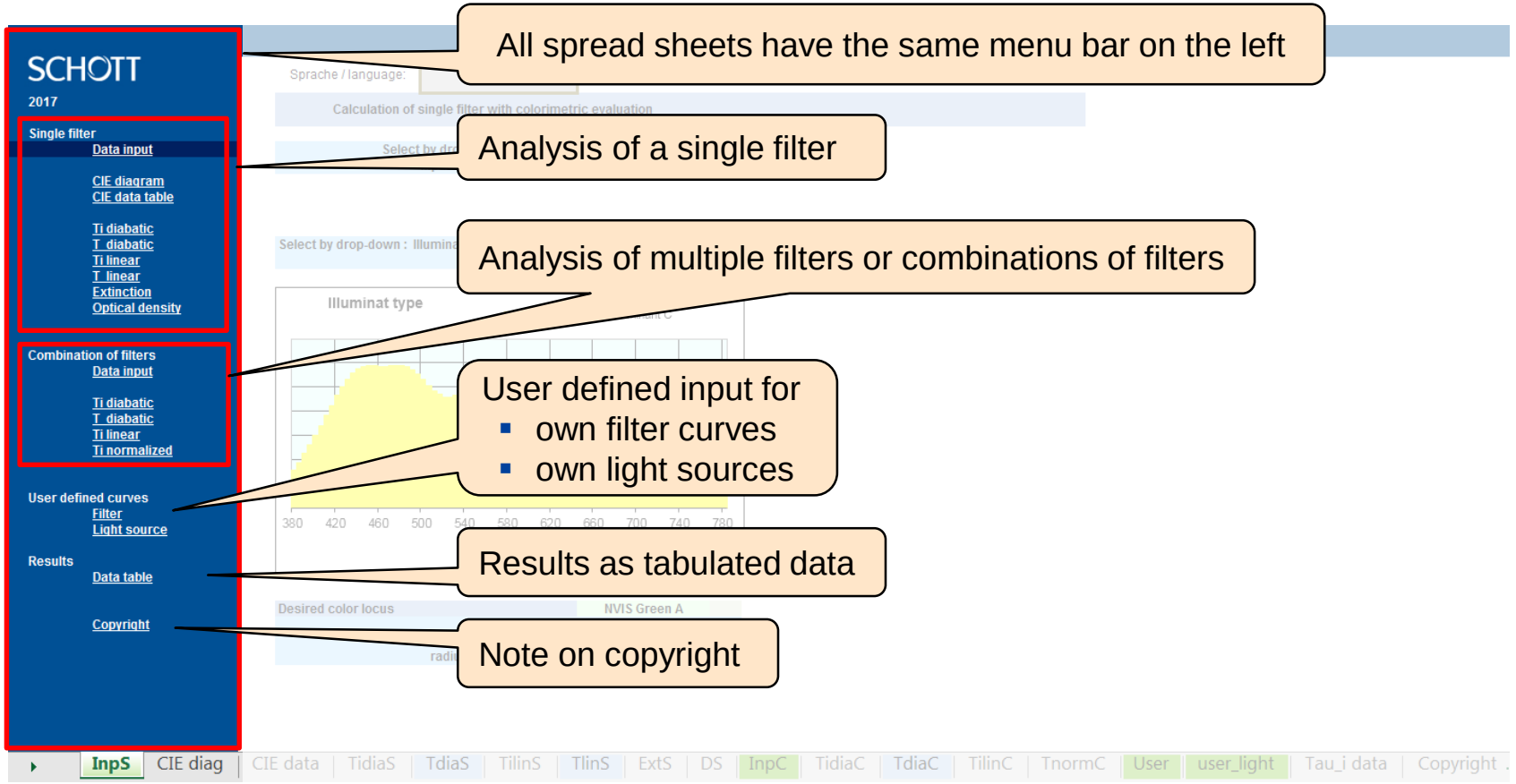
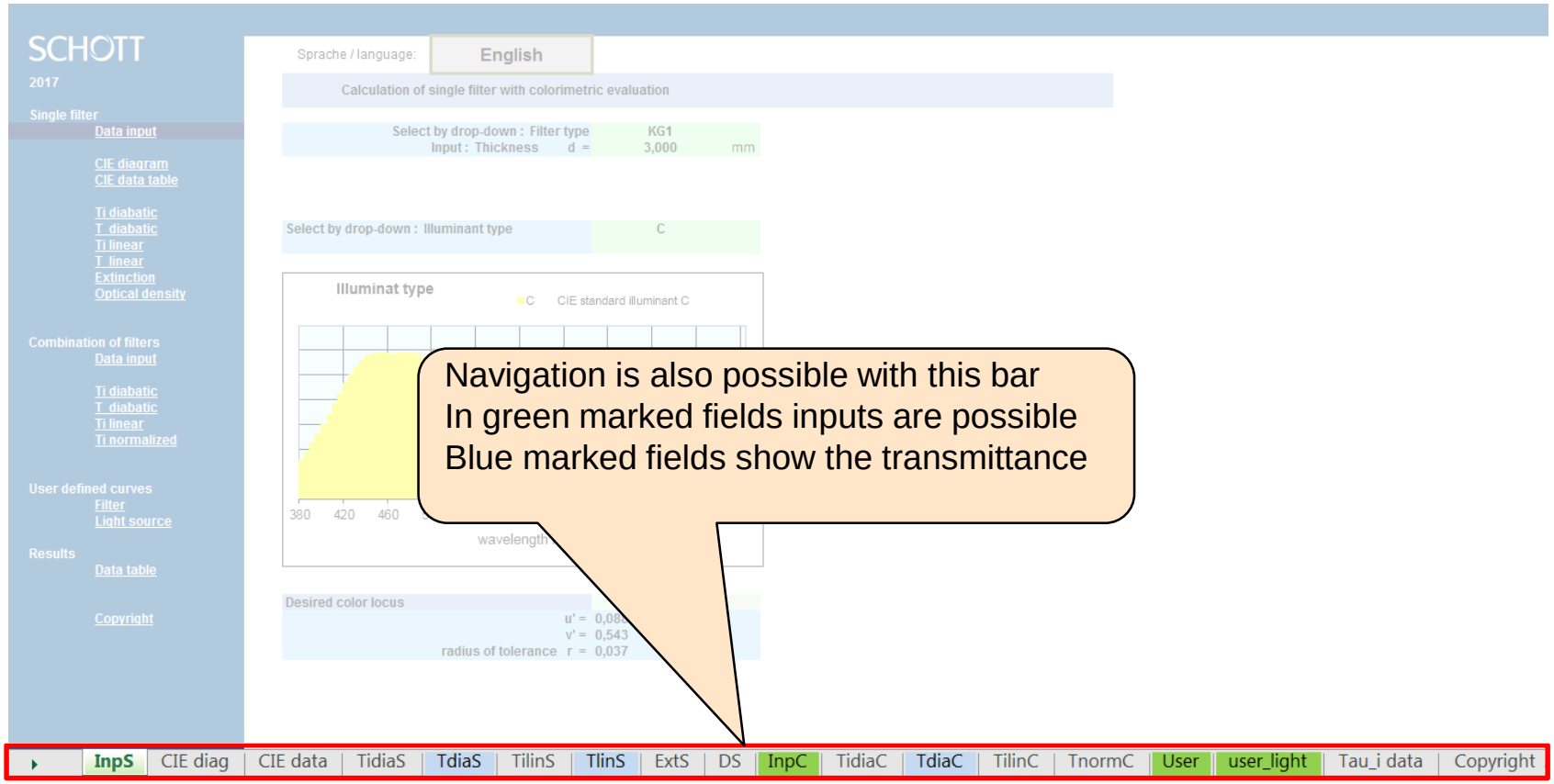
Menus and Overview



Navigation



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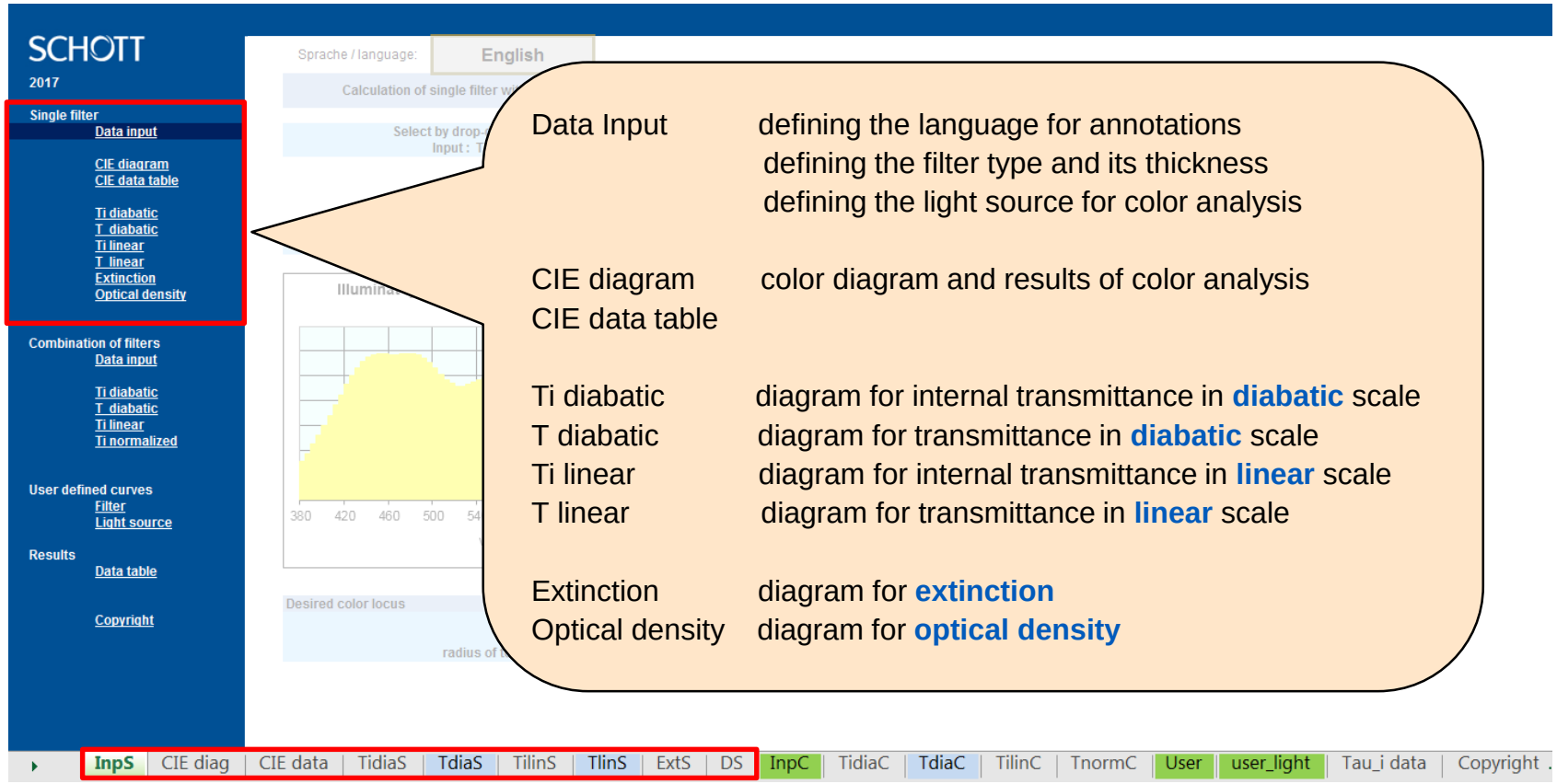
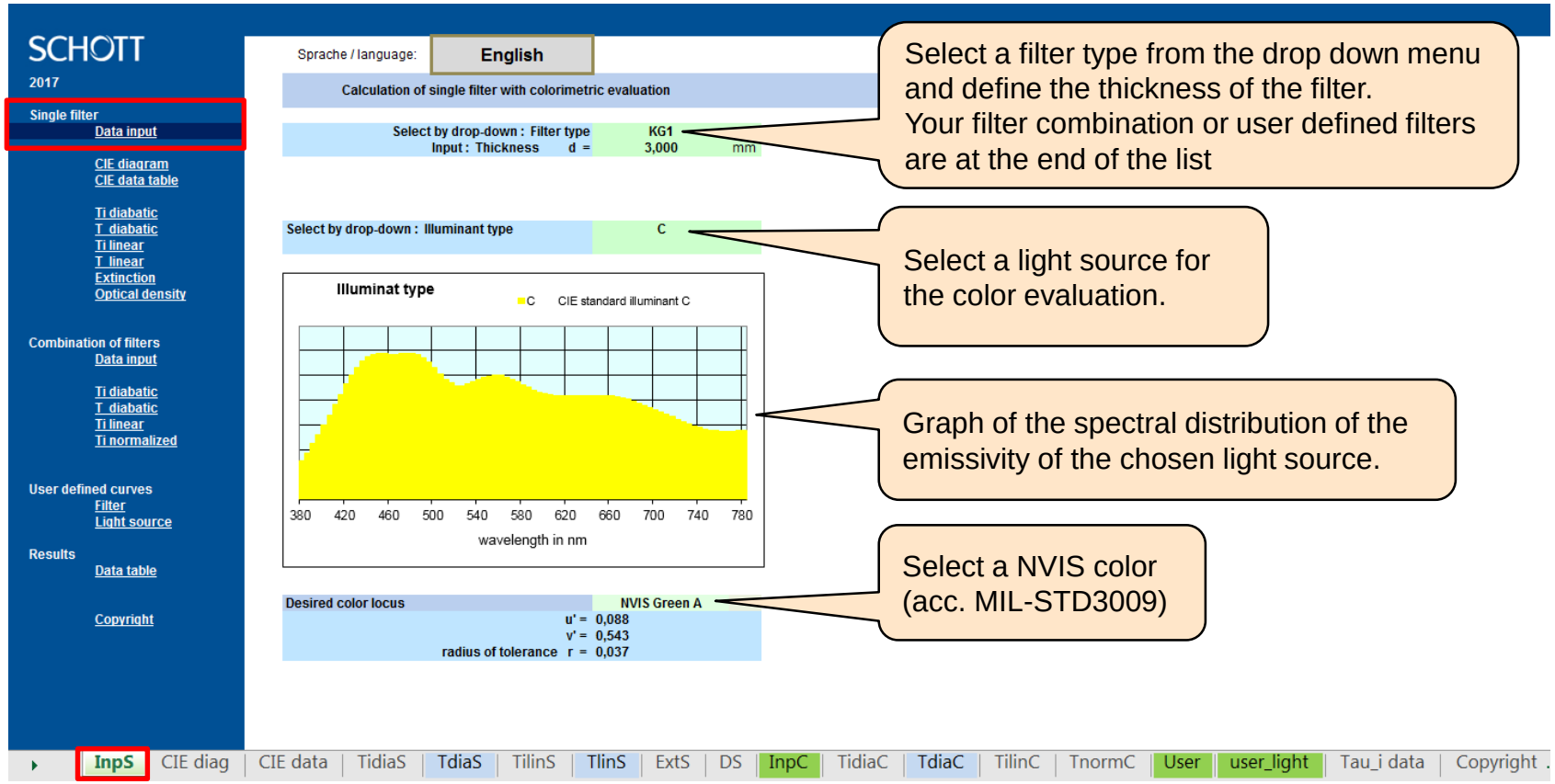
There are 9 sheets for analysis of a single filter



Data Input	defining the language for annotations defining the filter type and its thickness defining the light source for color analysis
CIE diagram CIE data table	color diagram and results of color analysis
Ti diabatic	diagram for internal transmittance in **diabatic** scale
T diabatic	diagram for transmittance in **diabatic** scale
Ti linear	diagram for internal transmittance in **linear** scale
T linear	diagram for transmittance in **linear** scale
Extinction	diagram for **extinction**
Optical density	diagram for **optical density**

Single filter: Data Input



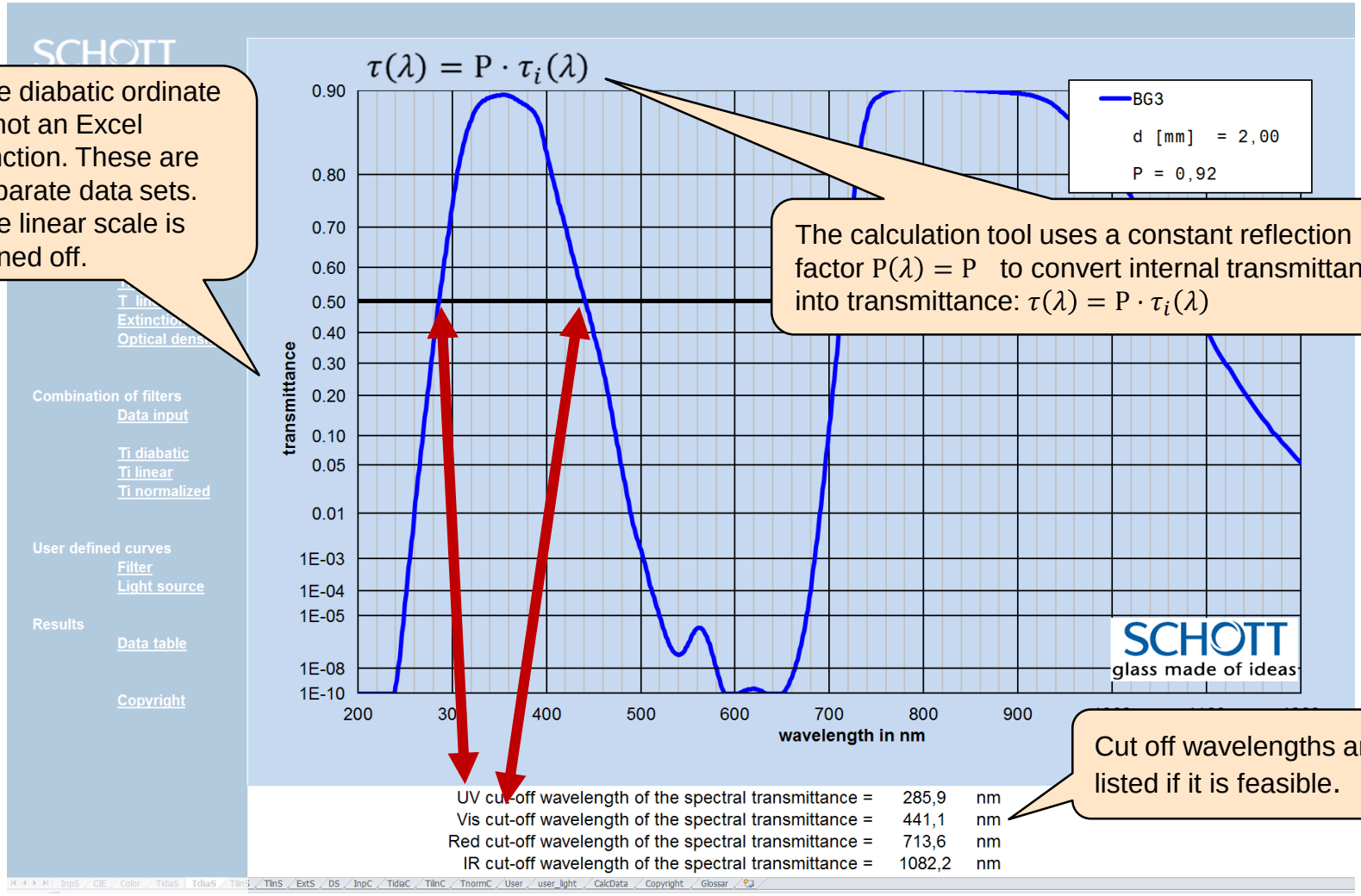
Select a filter type from the drop down menu and define the thickness of the filter.
Your filter combination or user defined filters are at the end of the list

Select a light source for the color evaluation.

Graph of the spectral distribution of the emissivity of the chosen light source.

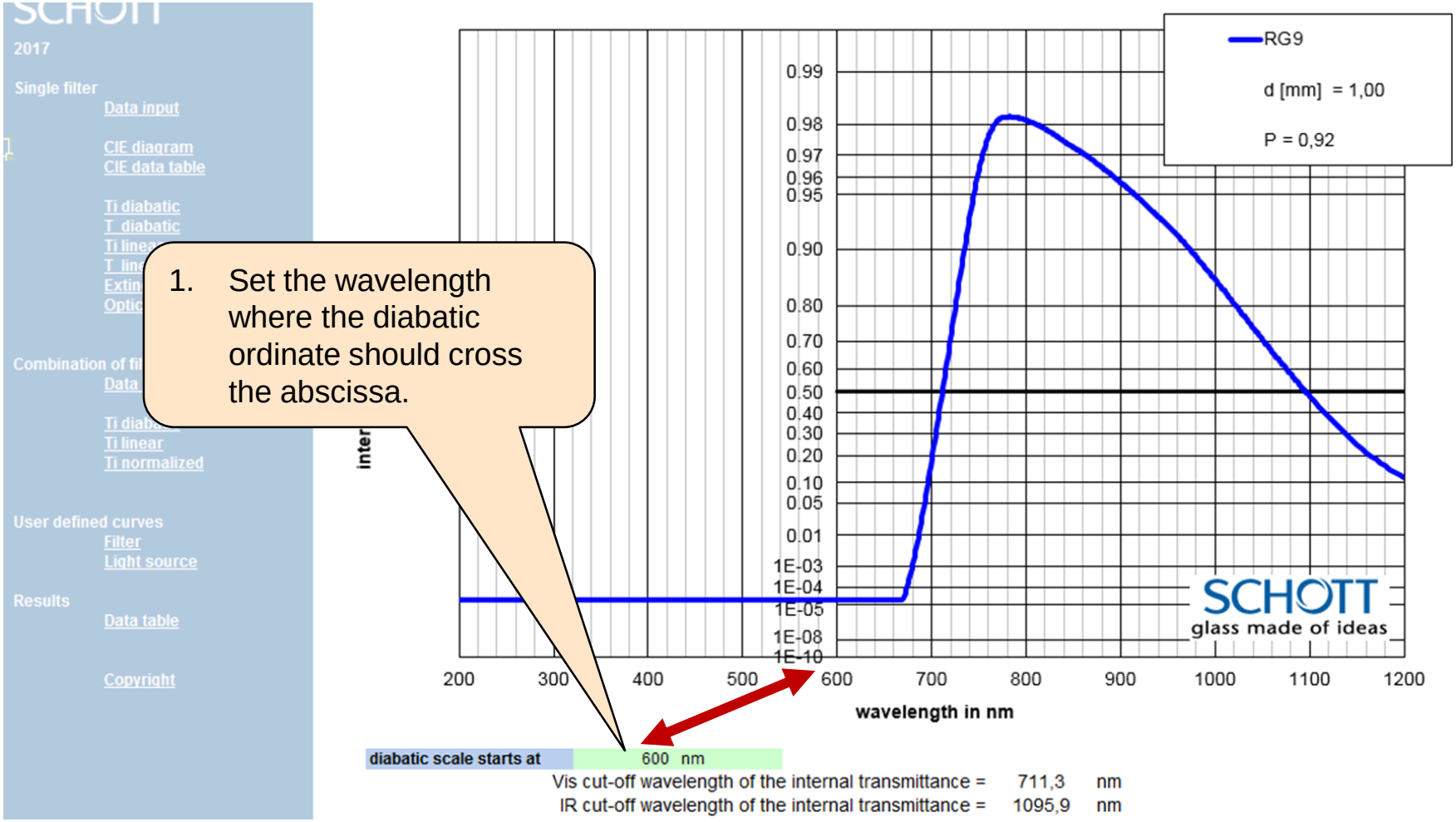
Select a NVIS color (acc. MIL-STD3009)

Single filter: Transmittance and internal transmittance



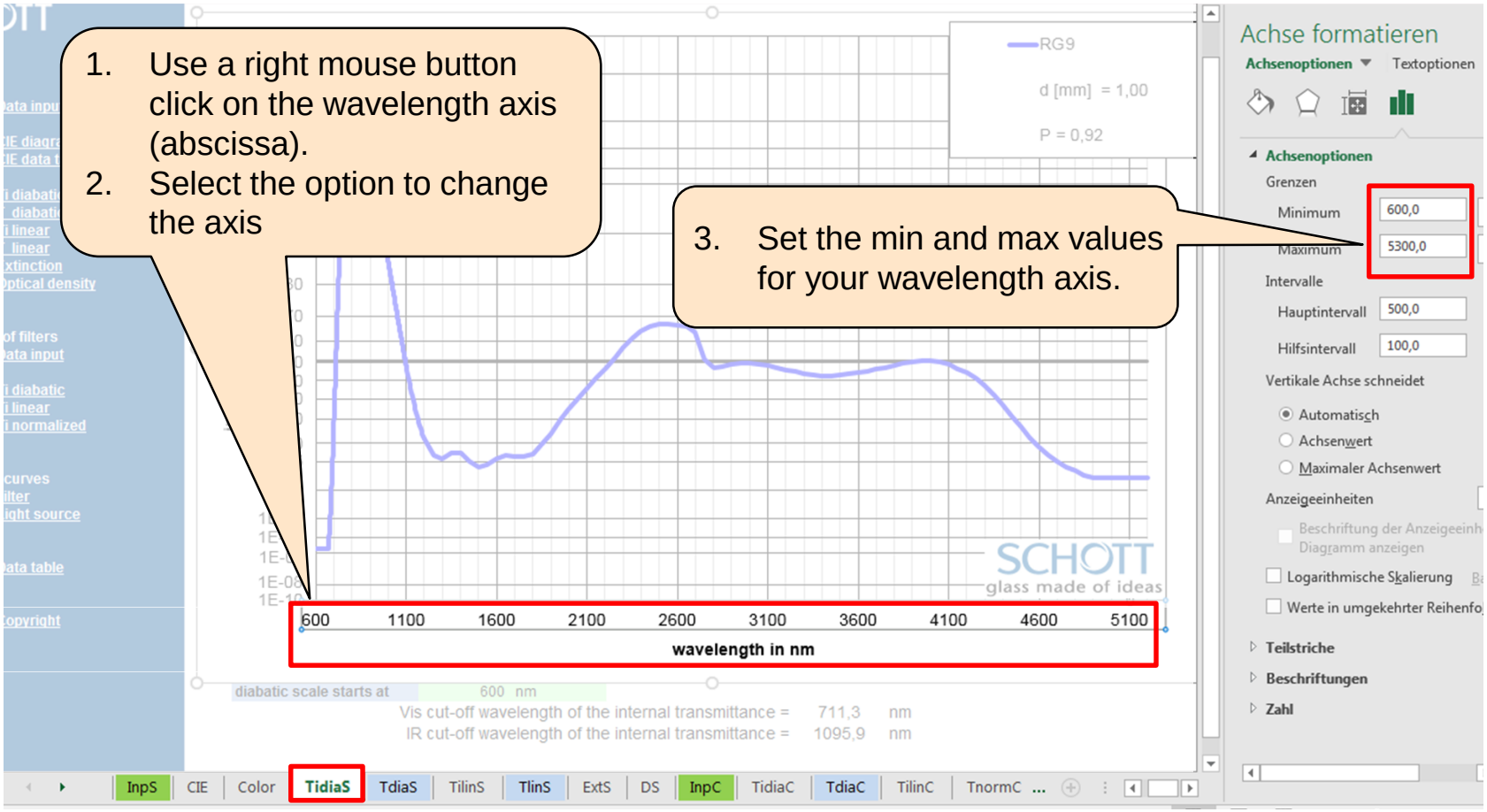
Single filter: IR data and changing the wavelength range

(1) wavelength change for diabatic scale



Single filter: IR data and changing the wavelength range

(2) change of wavelength range



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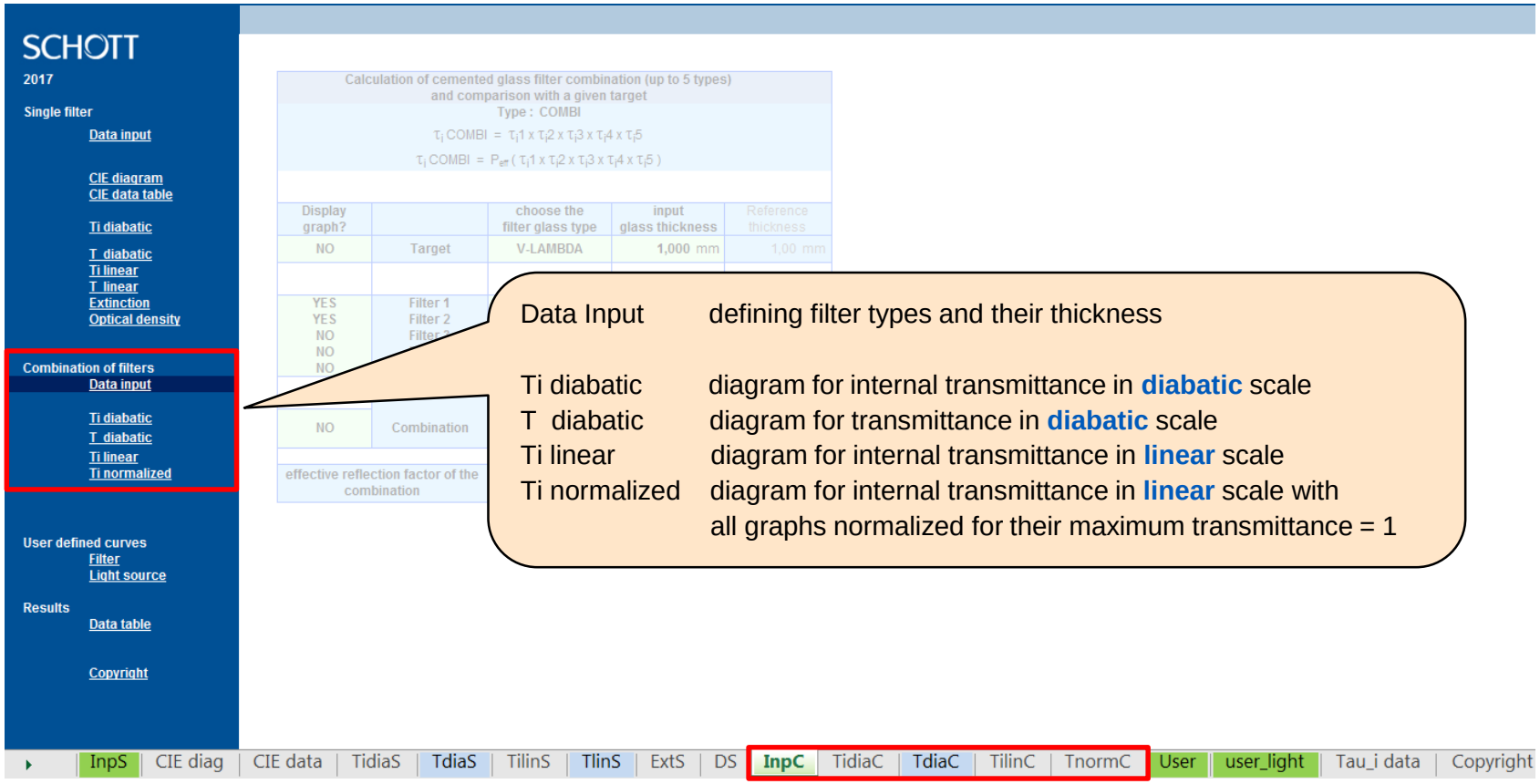
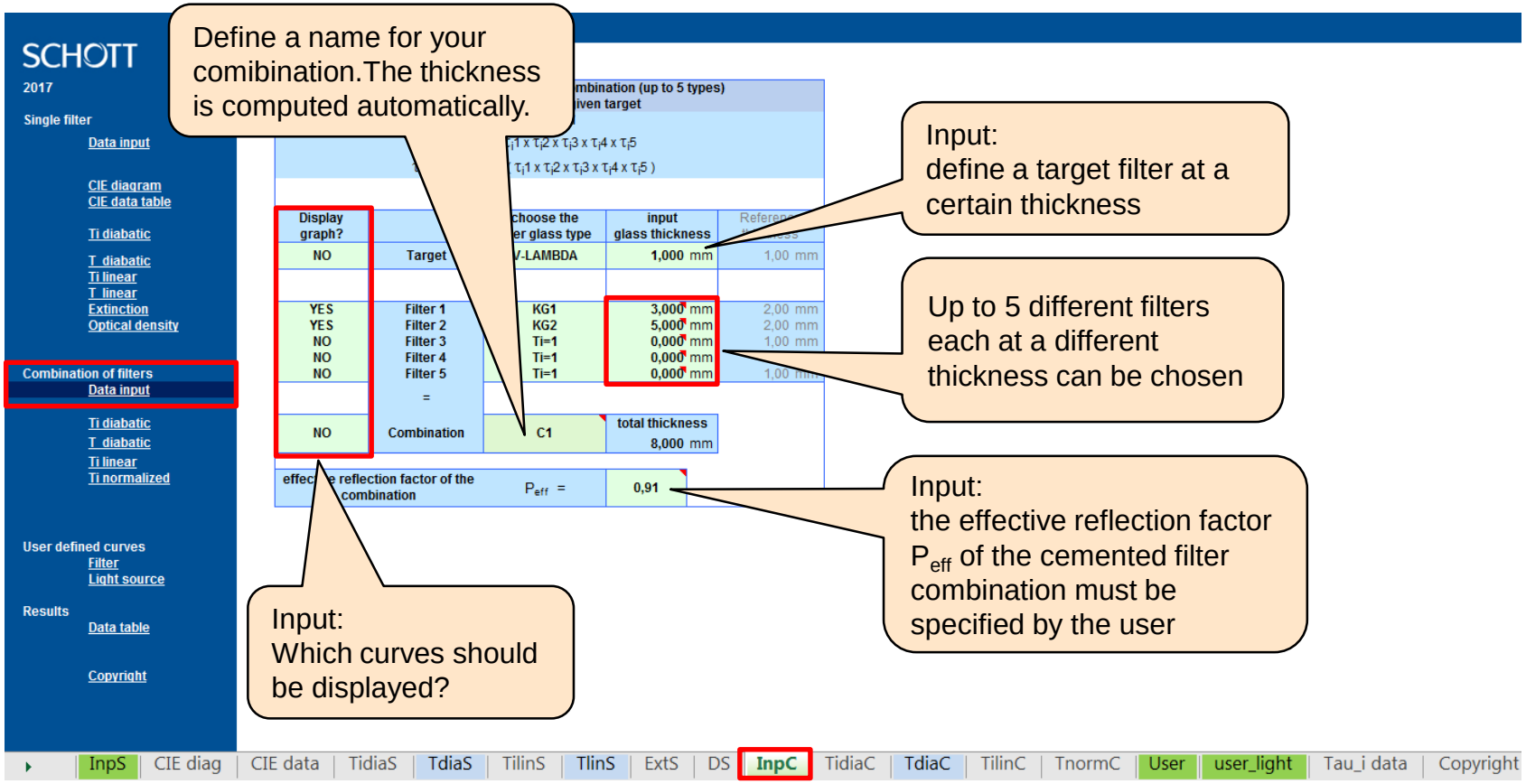
Comparing /Combining filters: There are 4 sheets for multiple filter analysis

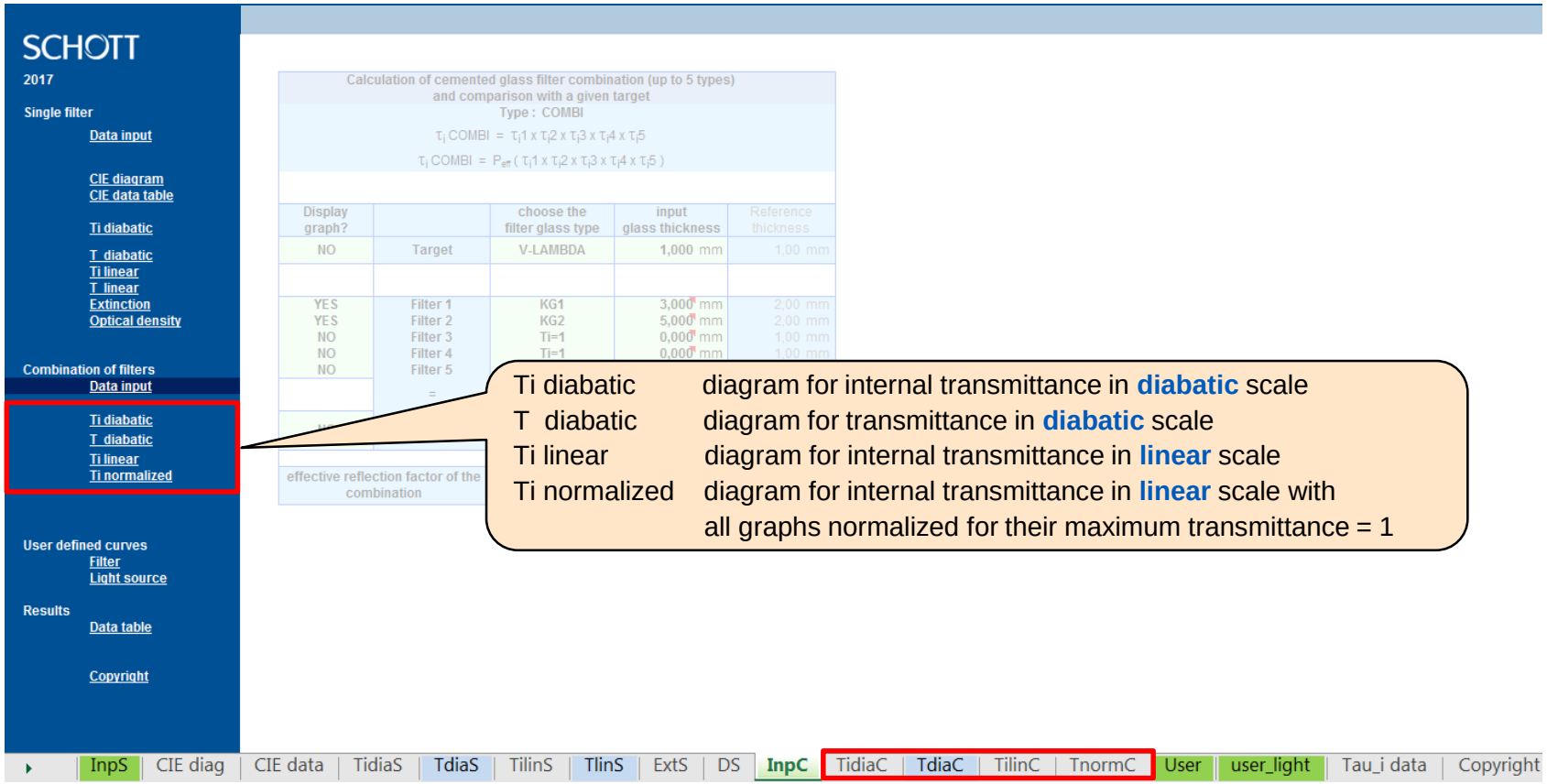


Data Input	defining filter types and their thickness
Ti diabatic	diagram for internal transmittance in **diabatic** scale
T diabatic	diagram for transmittance in **diabatic** scale
Ti linear	diagram for internal transmittance in **linear** scale
Ti normalized	diagram for internal transmittance in **linear** scale with all graphs normalized for their maximum transmittance = 1

Comparing filters: defining filter types and other input

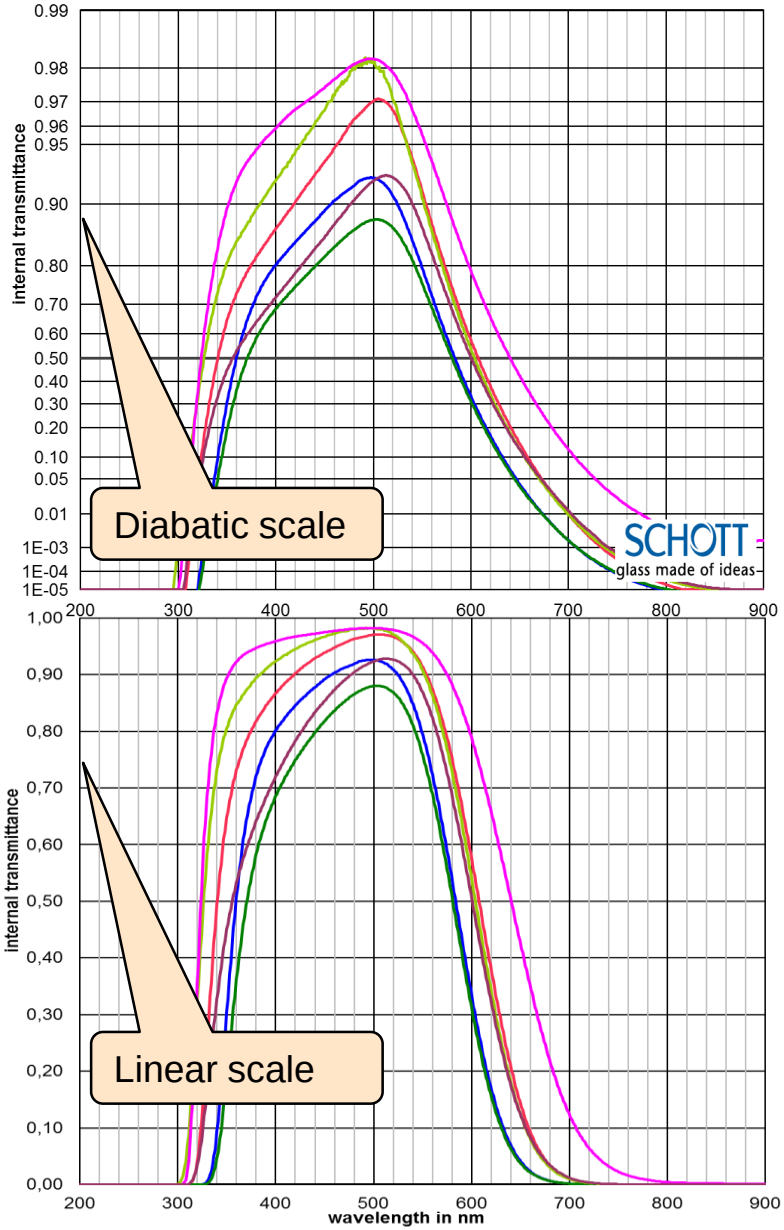


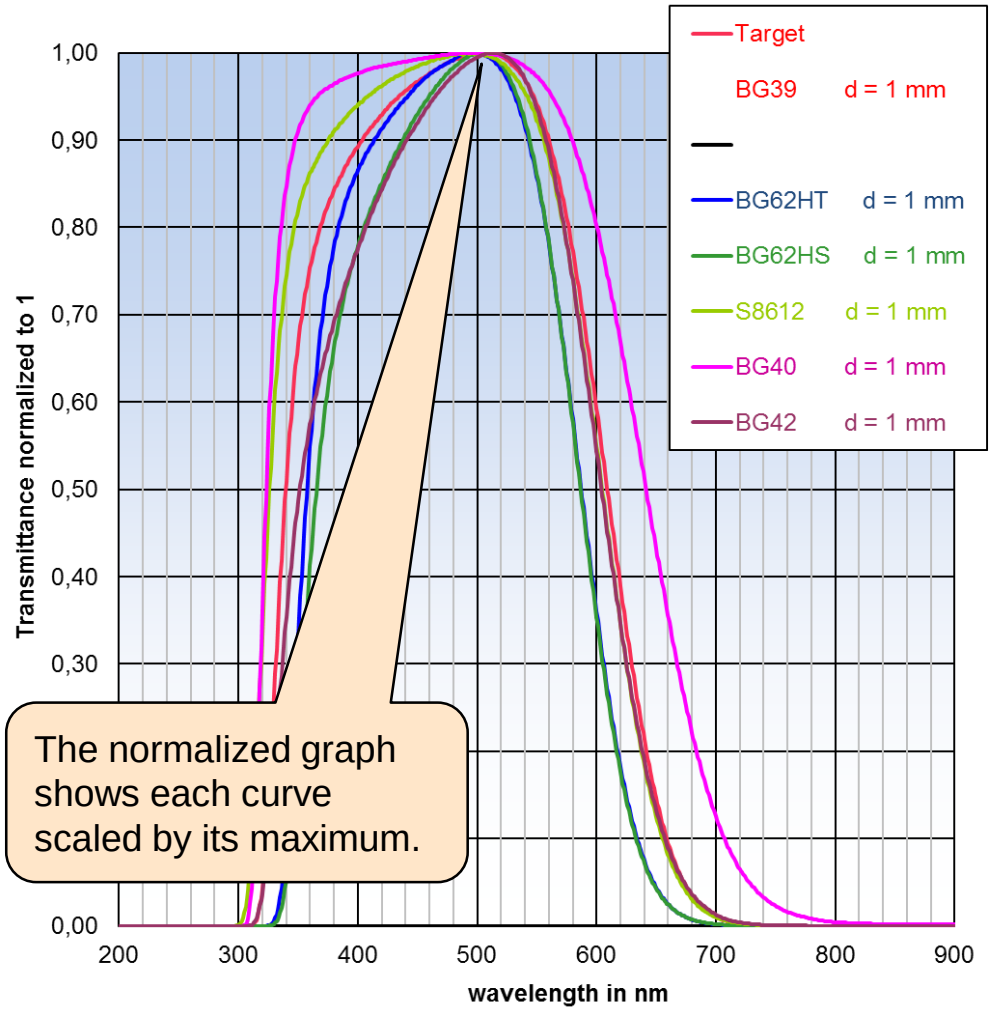
Comparing /Combining filters: There are 4 sheets for multiple filter analysis



Ti diabatic	diagram for internal transmittance in **diabatic** scale
T diabatic	diagram for transmittance in **diabatic** scale
Ti linear	diagram for internal transmittance in **linear** scale
Ti normalized	diagram for internal transmittance in **linear** scale with all graphs normalized for their maximum transmittance = 1

Comparing filters: diabatic, linear, normalized scale





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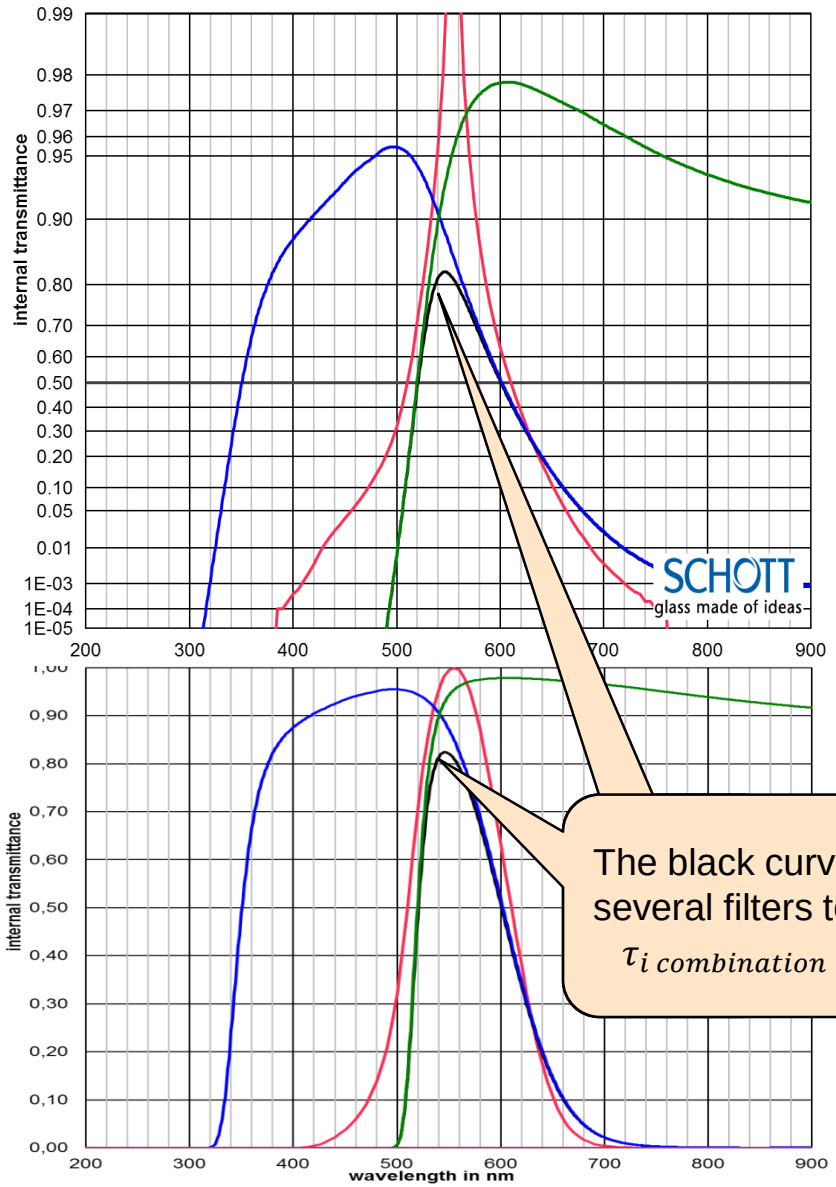
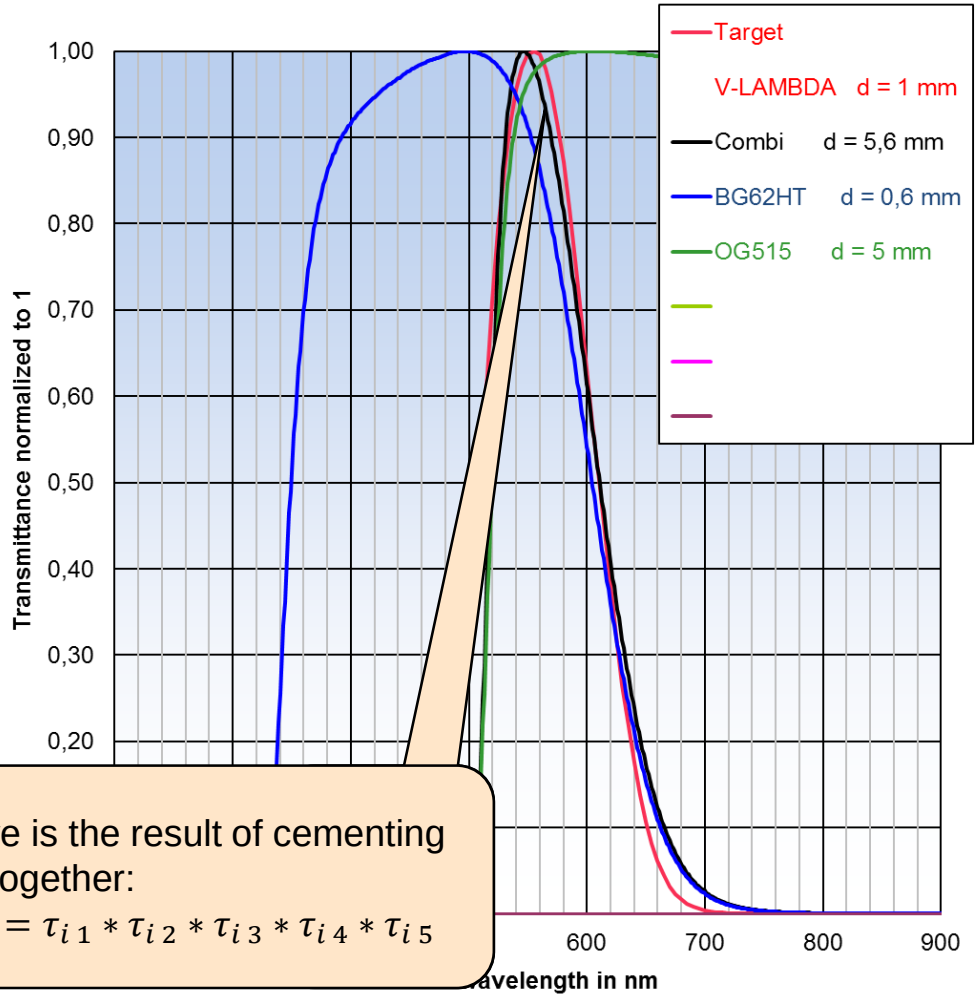
Combining filters:
internal transmittance in diabatic, linear, normalized scale





The black curve is the result of cementing several filters together:

$$\tau_{i\,combination} = \tau_{i\,1} * \tau_{i\,2} * \tau_{i\,3} * \tau_{i\,4} * \tau_{i\,5}$$

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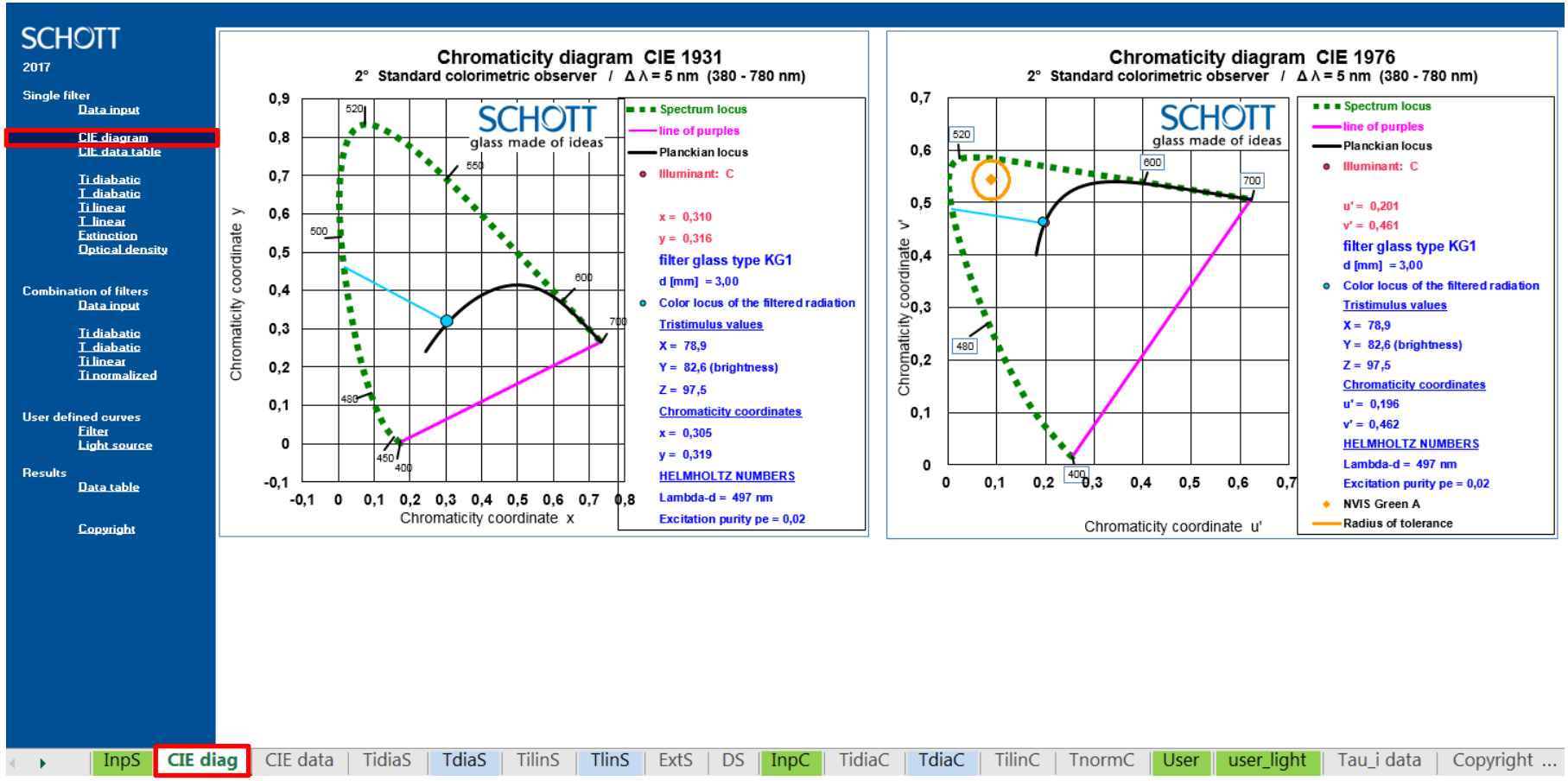
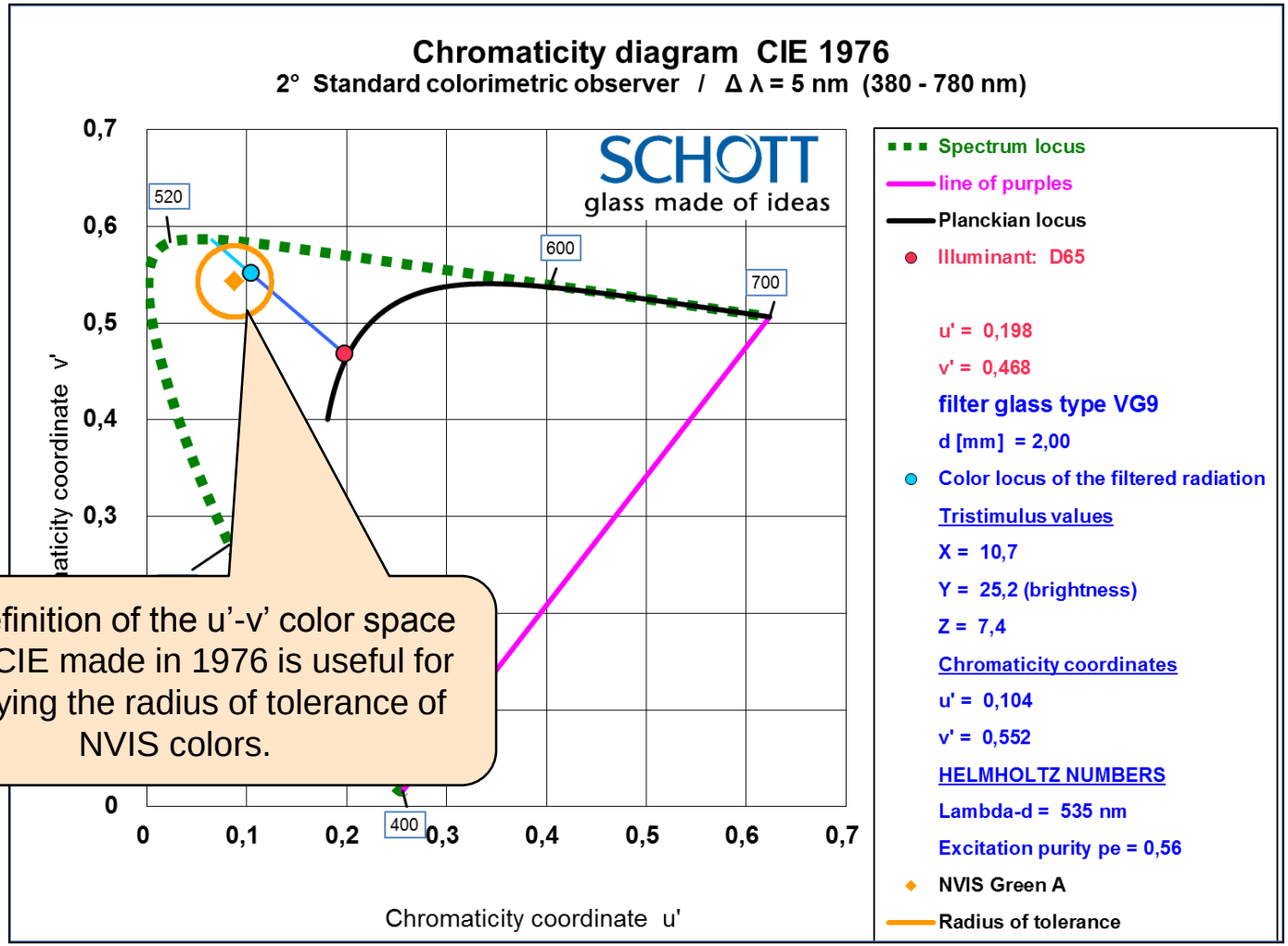
Color of light source and filtered radiation

- All required data input for color analysis has to be given in the sheet „**Data input**“ for a single filter.
- The user can choose any single filter glass type or the cemented combination of several filter glasses, which are given in the sheet „**Data input**“ for „**Combinations of filters**.“
- The color of filtered radiation is a function of
    - the filter glass type
    - the filter glass thickness
    - the light source
- The color of a light source or filtered radiation can be described by the definitions of the CIE made in 1931 and 1976. The results are given as a graph or tabulated data

There are two types of color diagrams available:
x-y- or **u'-v'-** chromaticity diagram

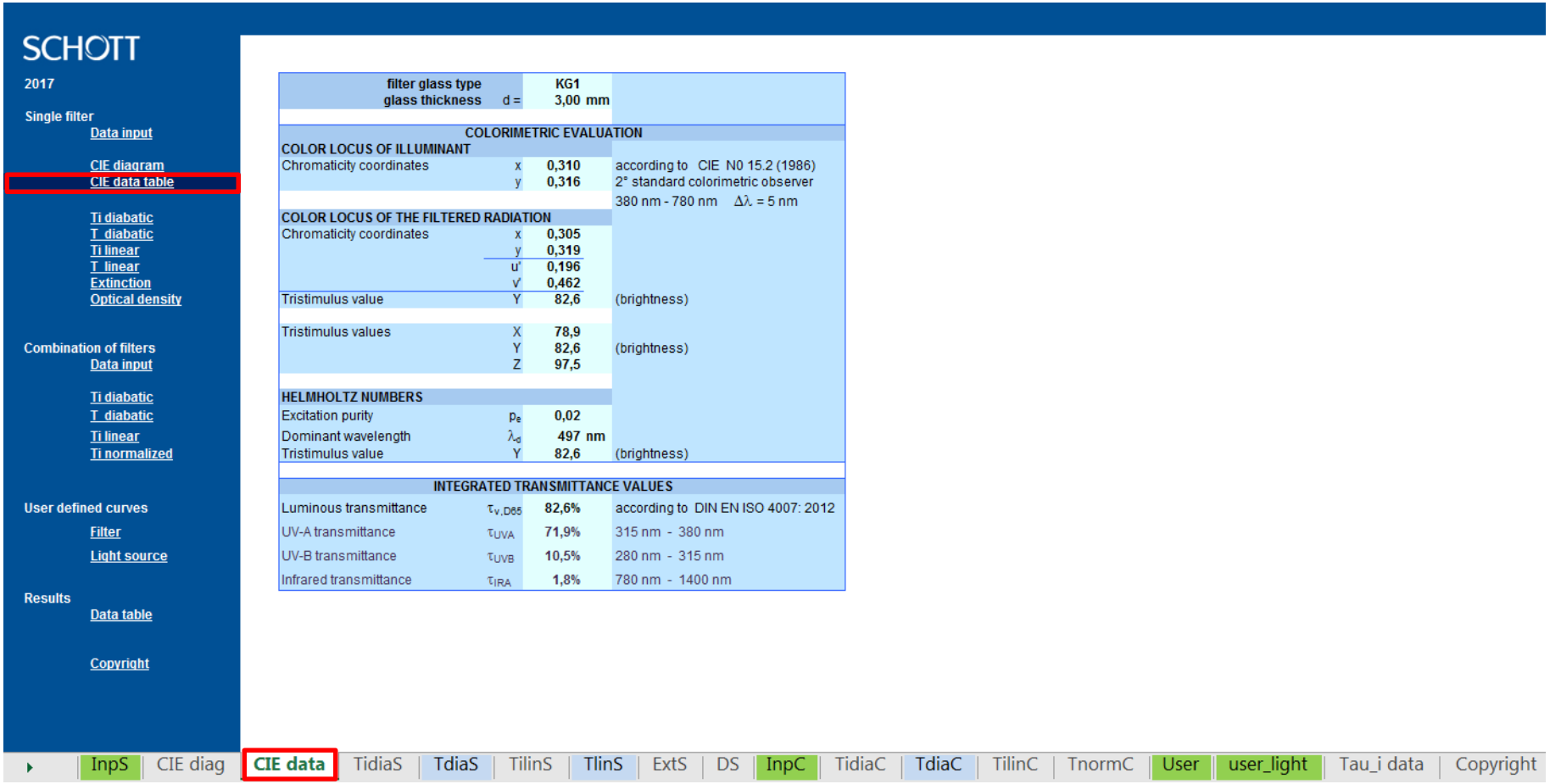


Color of filtered radiation in u’-v’-coordinates



The definition of the u’-v’ color space of the CIE made in 1976 is useful for displaying the radius of tolerance of NVIS colors.

Color of light source and filtered radiation



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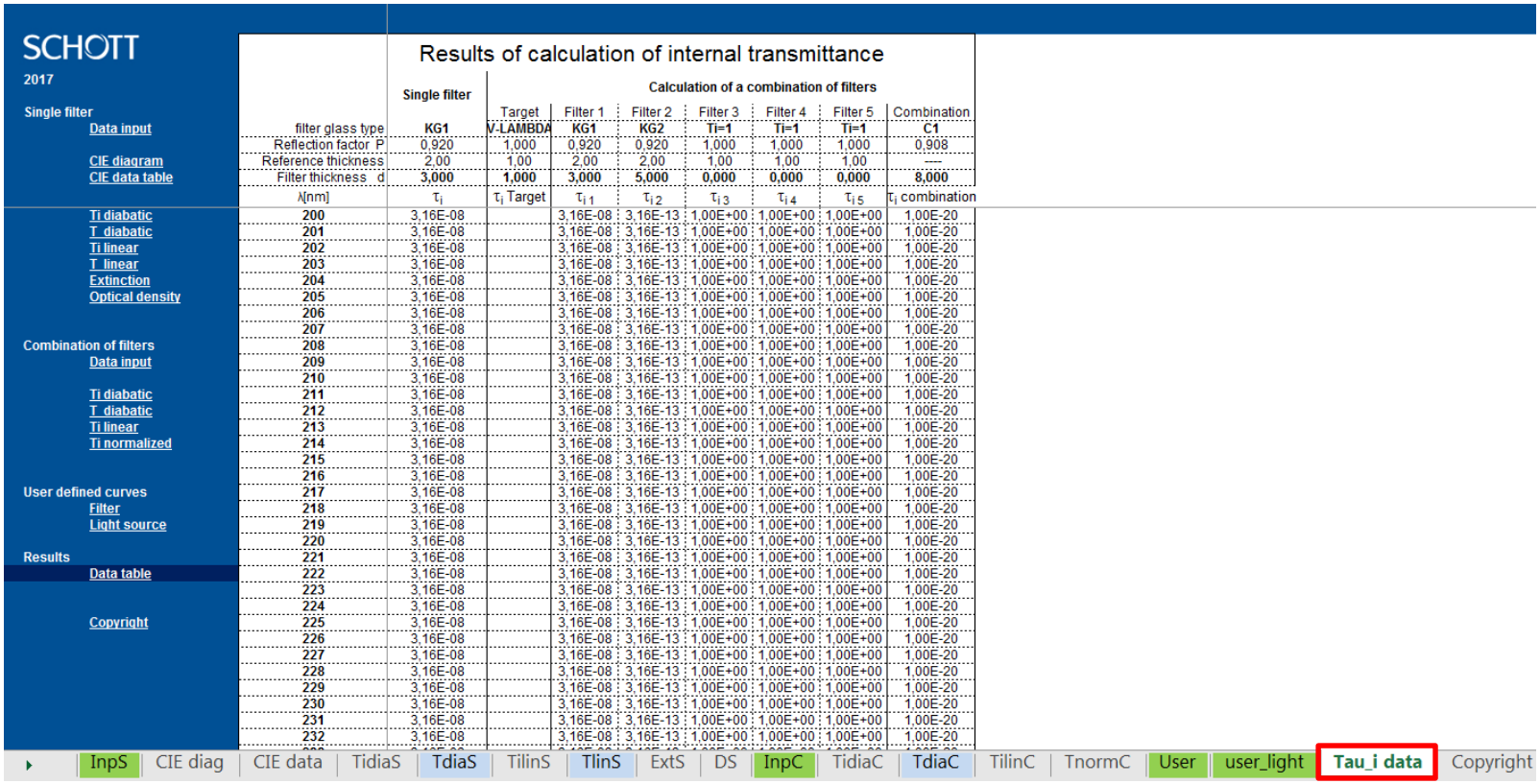
The internal transmittance data is listed for the specified thicknesses

- The sheet „**Tau_i data**“ contains the internal transmittance data for the chosen filter types.
- The data is listed from 200 to 1100 nm in steps of 1 nm and from 1200 nm to 5200 nm in steps of 50 nm.



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Single filter
Data input
CIE diagram
CIE data table
Ti diabatic
T diabatic
Ti linear
T linear
Extinction
Optical density
Combination of filters
Data input
Ti diabatic
T diabatic
Ti linear
Ti normalized
User defined curves
Filter
Light source
Results
Data table
Copyright

Results of calculation of internal transmittance

		Single filter	Calculation of a combination of filters						
			Target	Filter 1	Filter 2	Filter 3	Filter 4	Filter 5	Combination
	filter glass type	KG1	V-LAMBDA	KG1	KG2	Ti=1	Ti=1	Ti=1	C1
	Reflection factor P	0,920	1,000	0,920	0,920	1,000	1,000	1,000	0,908
	Reference thickness	2,00	1,00	2,00	2,00	1,00	1,00	1,00	---
	Filter thickness d	3,000	1,000	3,000	5,000	0,000	0,000	0,000	8,000
	λ[nm]	τ_i	τ_i Target	$\tau_{i\,1}$	$\tau_{i\,2}$	$\tau_{i\,3}$	$\tau_{i\,4}$	$\tau_{i\,5}$	τ_i combination
	200	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	201	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	202	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	203	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	204	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	205	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	206	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	207	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	208	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	209	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	210	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	211	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	212	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	213	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	214	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	215	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	216	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	217	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	218	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	219	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	220	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	221	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	222	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	223	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	224	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	225	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	226	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	227	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	228	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	229	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	230	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	231	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20
	232	3,16E-08		3,16E-08	3,16E-13	1,00E+00	1,00E+00	1,00E+00	1,00E-20

InpS | CIE diag | CIE data | TidiaS | TdiaS | TilinS | TlinS | ExtS | DS | InpC | TidiaC | TdiaC | TilinC | TnormC | User | user_light | Tau_i data | Copyright

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The user may define his own filter glass types

- The sheet „**User**“ has space for 100 different filter curves.
- The internal transmittance has to be given in values ranging from $0 < \tau_i < 1$.

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Single filter
Data input

CIE diagram
CIE data table

Ti diabatic
T_diabatic
Ti linear
T_linear
Extinction
Optical density

Combination of filters
Data input

Ti diabatic
T_diabatic
Ti linear
Ti normalized

User defined curves
Filter
Light source

Results
Data table

Copyright

User type name	V-LAMBDA	Mycurve	upper limit	linear	coating	water							
Reflection factor P	1,00	0,90	0,90	0,90	1,00	0,96							
Reference thickness in mm	1,00	2,00	1,00	1,00	1,00	1000,00							
free for text and notes	380 - 780 nm	Example	Example	Example	Example	stein (1981; Internet)							
λ[nm]	$\tau_{i\,01}$	$\tau_{i\,02}$	$\tau_{i\,03}$	$\tau_{i\,04}$	$\tau_{i\,05}$	$\tau_{i\,06}$	$\tau_{i\,07}$	$\tau_{i\,08}$	$\tau_{i\,09}$	$\tau_{i\,10}$	$\tau_{i\,11}$	$\tau_{i\,12}$	$\tau_{i\,13}$
200		0,001				9,90E-04							
201		0,001		0,15075		4,07E-03							
202		0,001		0,1515		7,15E-03							
203		0,001		0,15225		1,02E-02							
204		0,001		0,153		1,33E-02							
205		0,001		0,15375		1,64E-02							
206		0,001		0,1545		3,31E-02							
207		0,001		0,15525		4,99E-02							
208		0,001		0,156		6,66E-02							
209		0,001		0,15675		8,34E-02							
210		0,001		0,1575		1,00E-01							
211		0,001		0,15825		1,42E-01							
212		0,001		0,159		1,84E-01							
213		0,001		0,15975		2,26E-01							
214		0,001		0,1605		2,68E-01							
215		0,001		0,16125		3,11E-01							
216		0,001		0,162		3,45E-01							
217		0,001		0,16275		3,80E-01							
218		0,001		0,1635		4,14E-01							
219		0,001		0,16425		4,49E-01							
220		0,001		0,165		4,84E-01							
221		0,001		0,16575		4,92E-01							
222		0,001		0,1665		5,00E-01							
223		0,001		0,16725		5,08E-01							
224		0,001		0,168		5,16E-01							
225		0,001		0,16875		5,24E-01							
226		0,001		0,1695		5,28E-01							
227		0,001		0,17025		5,33E-01							
228		0,001		0,171		5,38E-01							
229		0,001		0,17175		5,43E-01							
230		0,001		0,1725		5,48E-01							
231		0,001		0,17325		5,51E-01							
232		0,001		0,174		5,54E-01							
233		0,001		0,17475		5,58E-01							
234		0,001		0,1755		5,61E-01							
235		0,001		0,17625		5,64E-01							

InpS | CIE diag | CIE data | TidiaS | TdiaS | TilinS | TlinS | ExtS | DS | InpC | TidiaC | TdiaC | TilinC | TnormC | User | user_light | Tau_i data | Copyright

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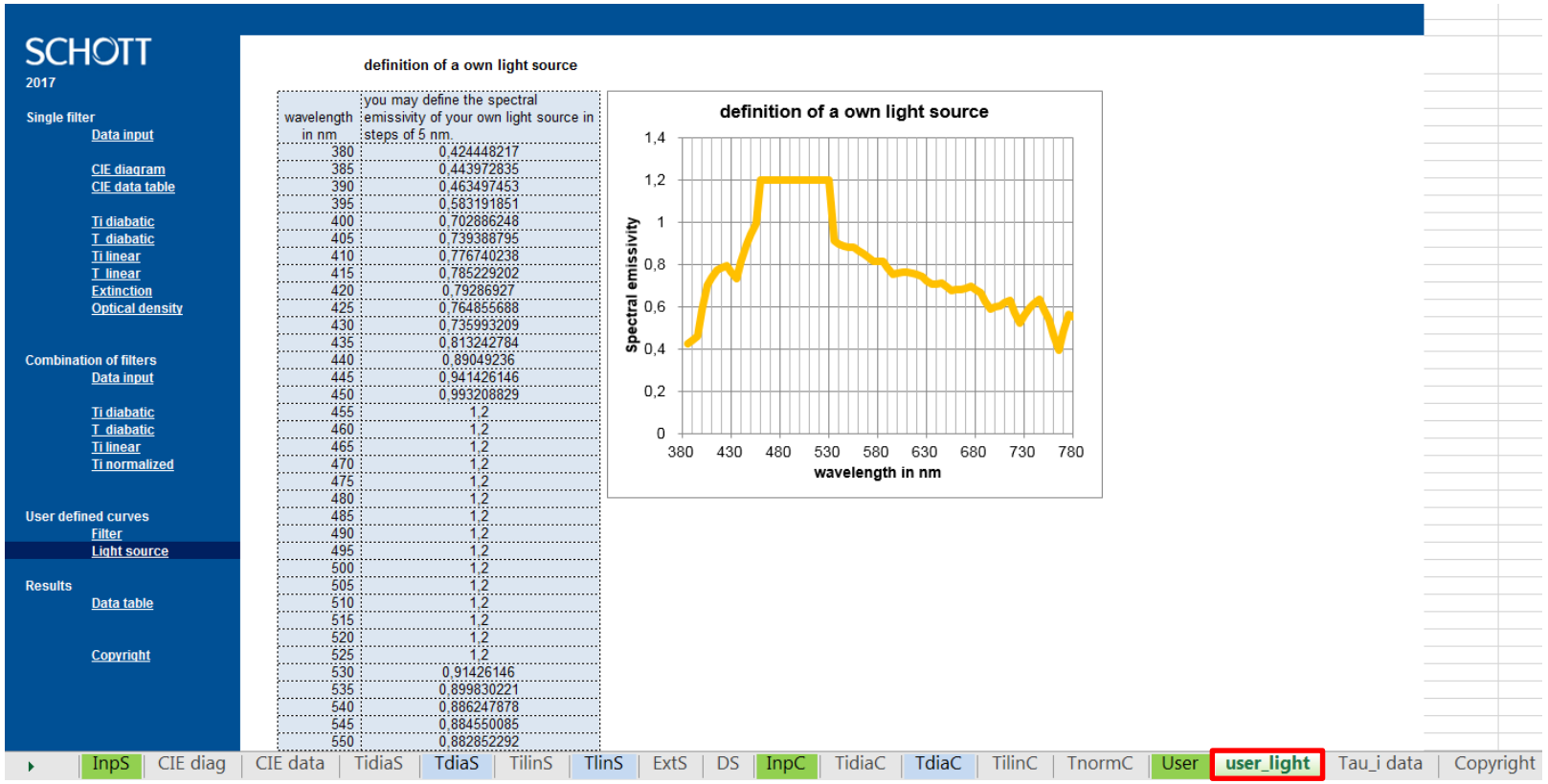
The user may define his own light source

- The sheet „**user_light**“ offers the possibility to define the spectrum of an own light source.
- The emissivity is normalized within the color analysis. Thus, the total intensity of the data input does not affect the results of color calculation.



Addendum

- Any comments or suggestions are welcome.

- If you have any questions or recommendations please contact your local sales representative.