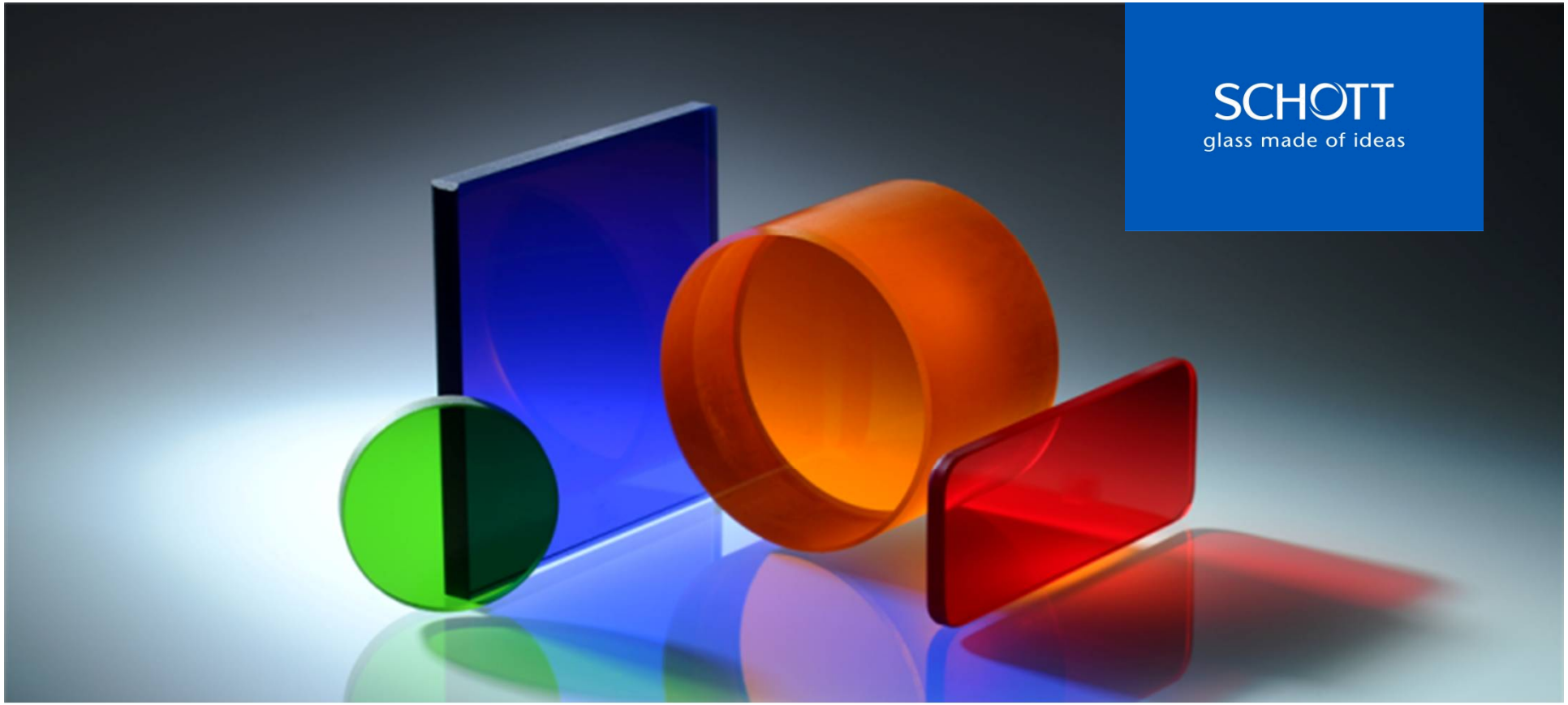


Tutorial on SCHOTT filter calculation tool

2015

Dr. Ralf Biertümpfel, April 2015

Agenda

1. Introduction

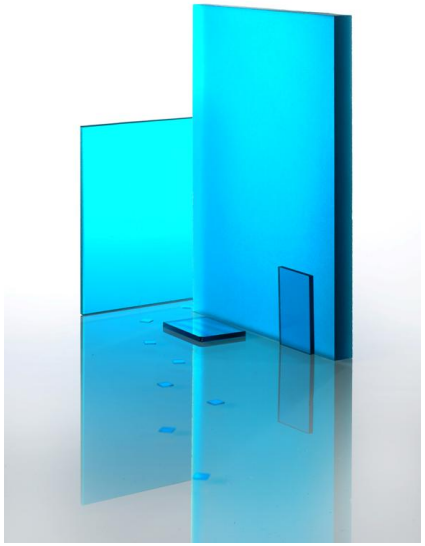
2. Properties of a single filter:
   transmittance and internal transmittance
   optical density an extinction

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



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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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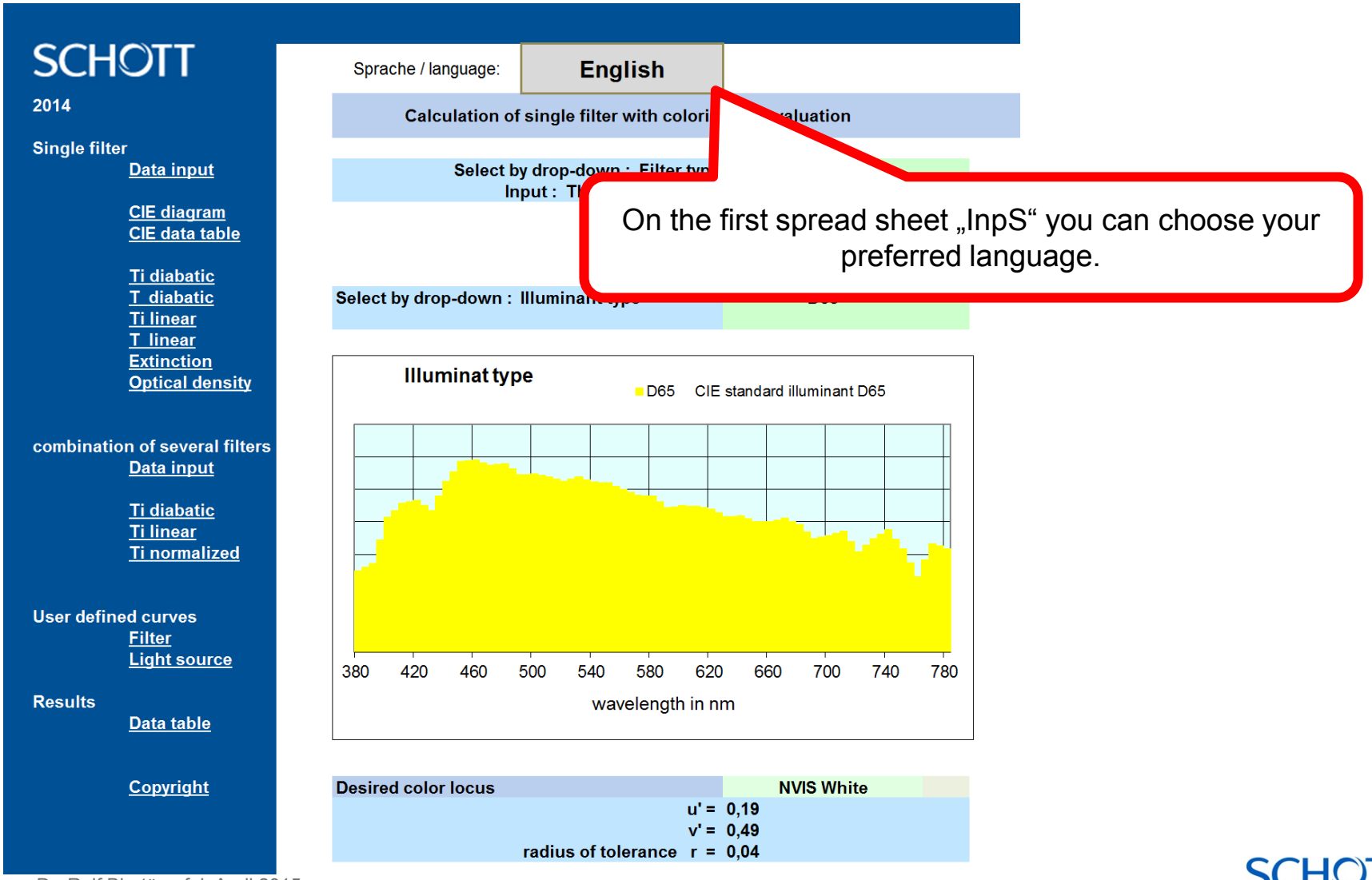
Language



On the first spread sheet „InpS“ you can choose your preferred language.

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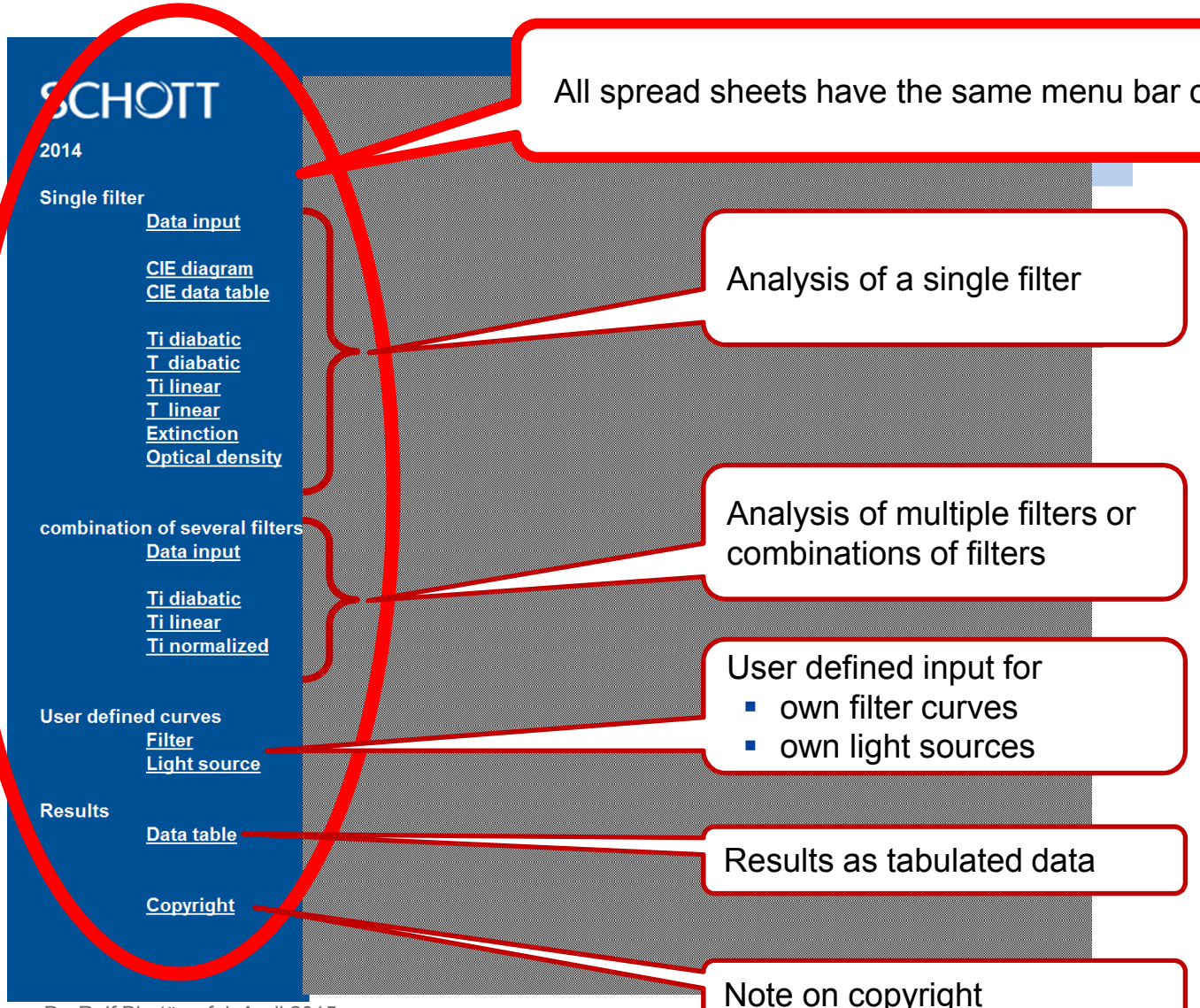
Menus and Overview



All spread sheets have the same menu bar on the left

Analysis of a single filter

Analysis of multiple filters or combinations of filters

User defined input for
- own filter curves
- own light sources

Results as tabulated data

Note on copyright

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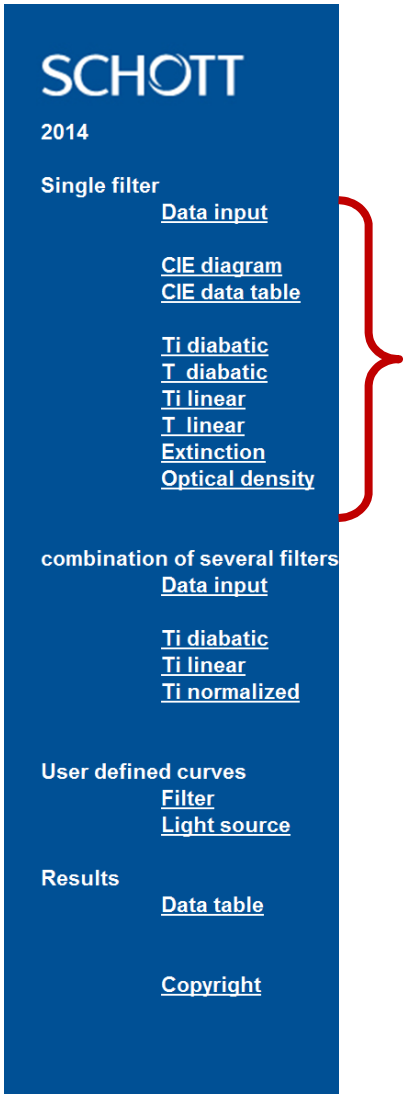
There are 9 sheets for analysis of a **single** filter



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

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single filter: Data Input

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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 several filters
- Data input
- Ti diabatic
- Ti linear
- Ti normalized

User defined curves
- Filter
- Light source

Results
- Data table

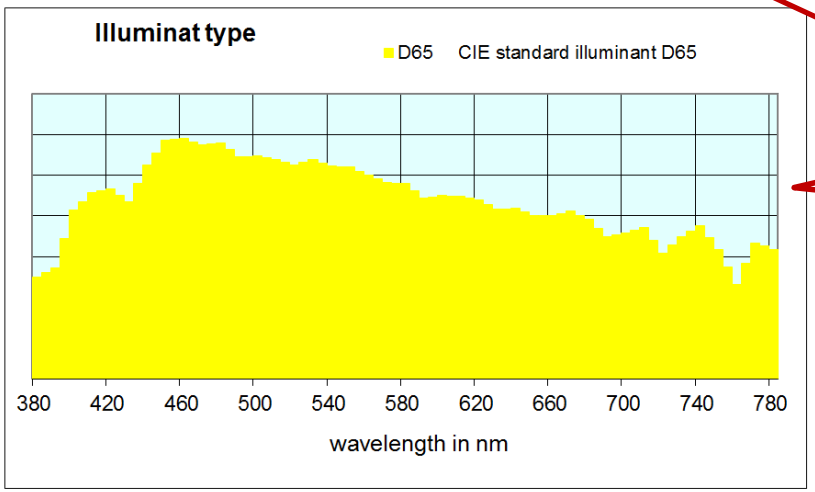
Copyright

Sprache / language: **English**

Calculation of single filter with colorimetric evaluation

Select by drop-down : Filter type		BG39	
Input : Thickness	d =	1,500	mm

Select by drop-down : Illuminant type: **D65**



Desired color locus		NVIS White
	u' =	0,19
	v' =	0,49
radius of tolerance	r =	0,04

You can choose the preferred language for this worksheet.

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)

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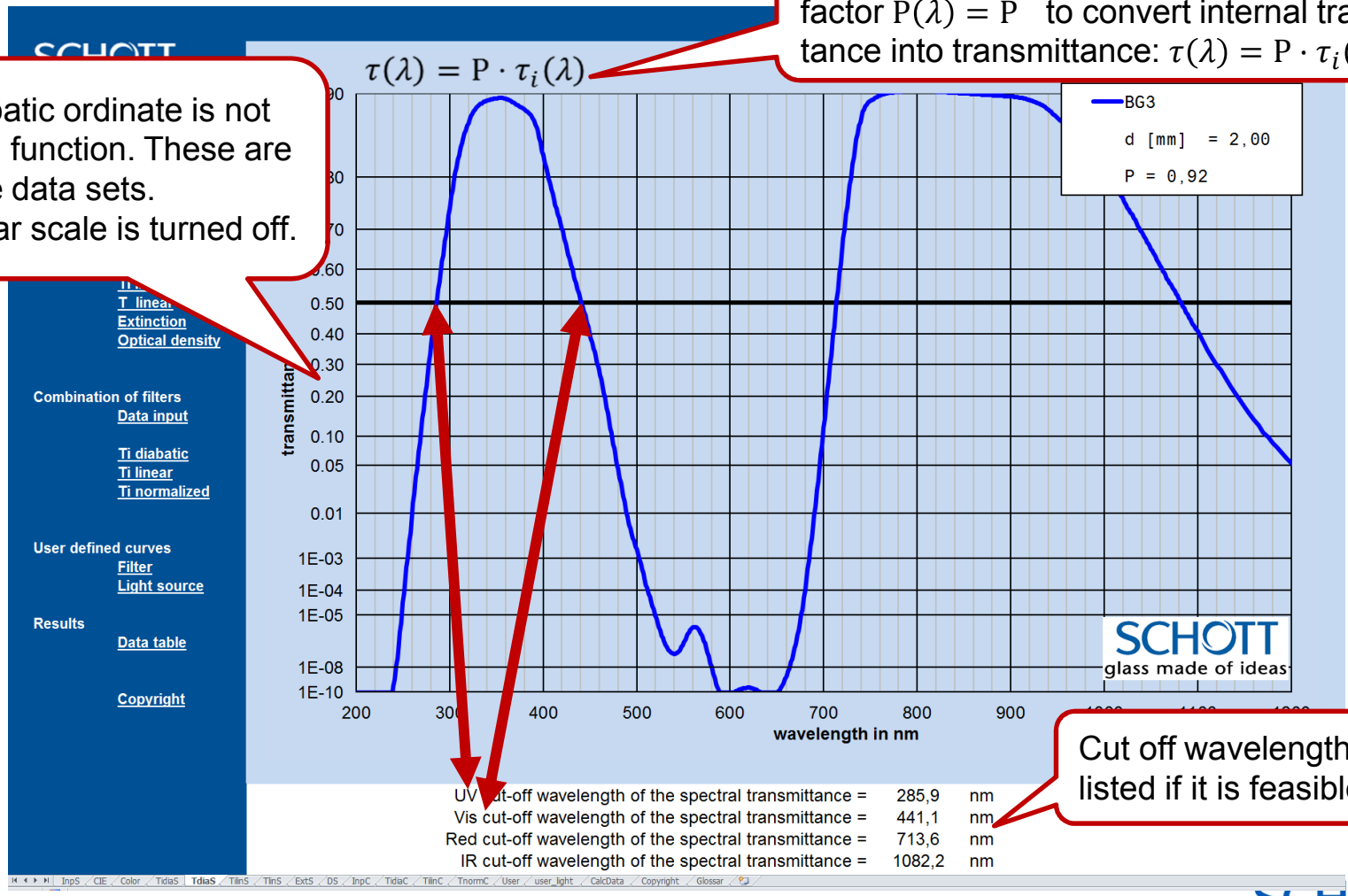
single filter: transmittance and internal transmittance
Transmissionsgrad und Reintransmissionsgrad

The calculation tool uses a constant reflection factor $P(\lambda) = P$ to convert internal transmittance into transmittance: $\tau(\lambda) = P \cdot \tau_i(\lambda)$

The diabatic ordinate is not an Excel function. These are seperate data sets.
The linear scale is turned off.



Cut off wavelengths are listed if it is feasible.

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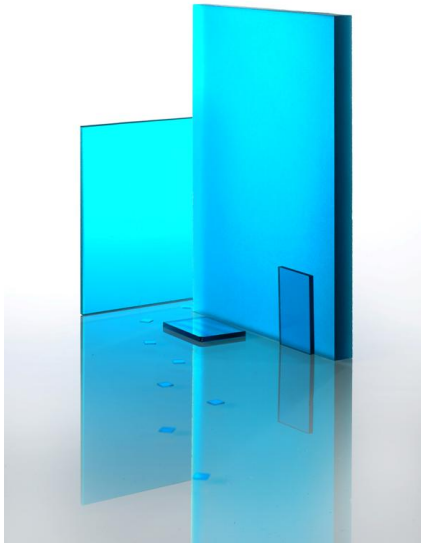

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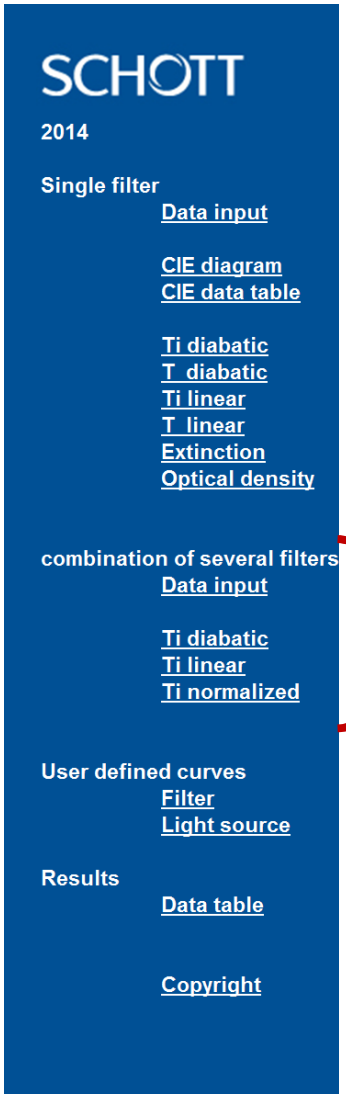
Comparing / combining filters:
There are 4 sheets for multiple filter analysis



Data Input:	defining filter types and their thickness
Ti diabatic	diagram for internal transmittance in ***diabatic*** scale
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

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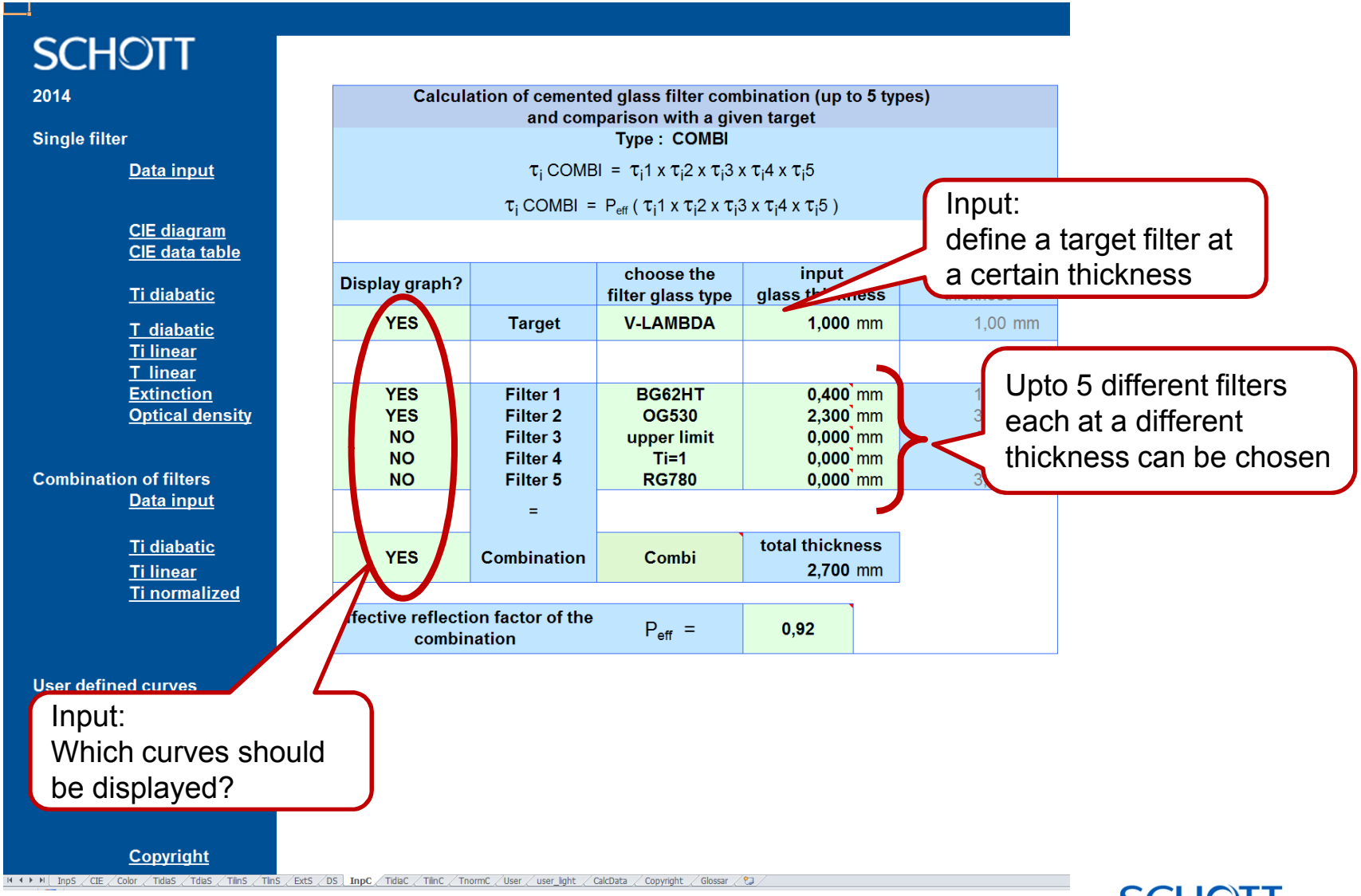
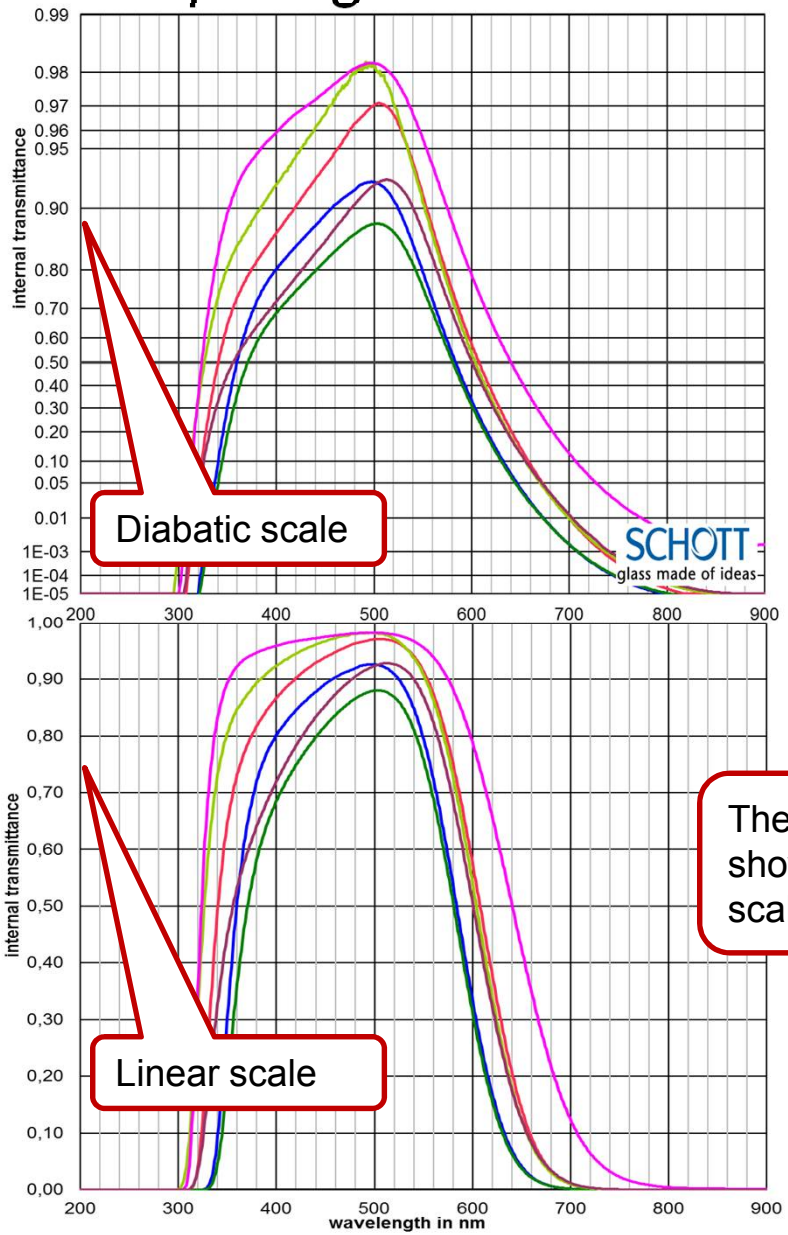
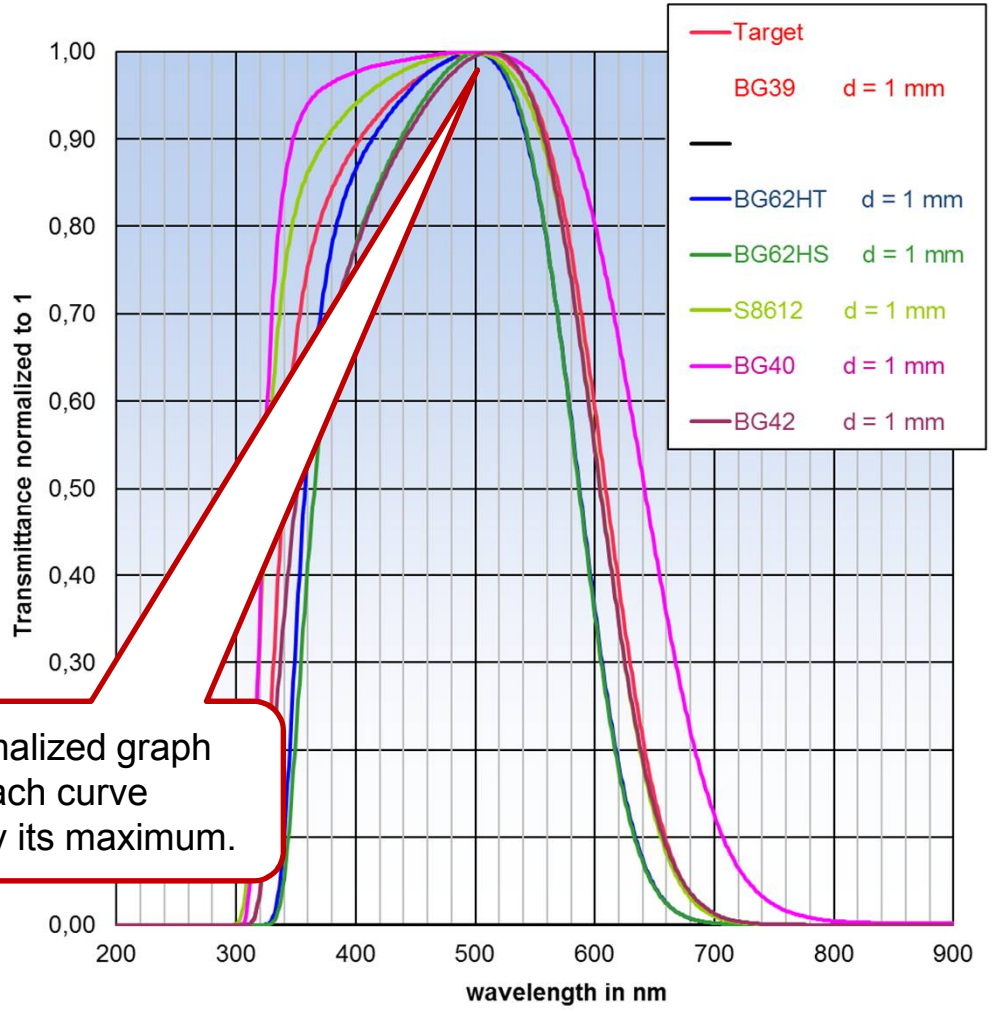
Comparing filters: defining filter types and their thickness



Comparing filters: diabatic, linear, normalized scale





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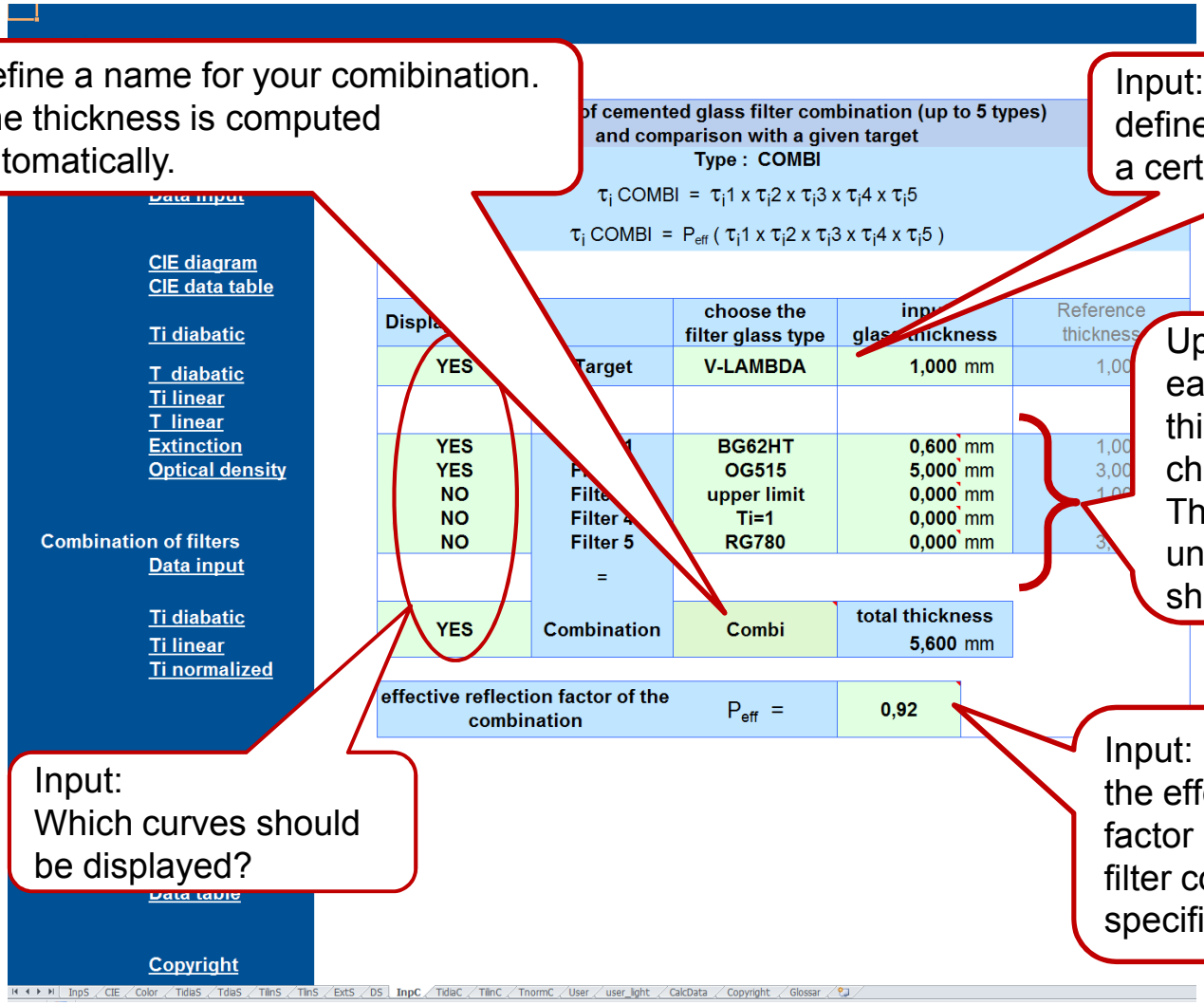
Combining filters:

defining name and the components of the combination



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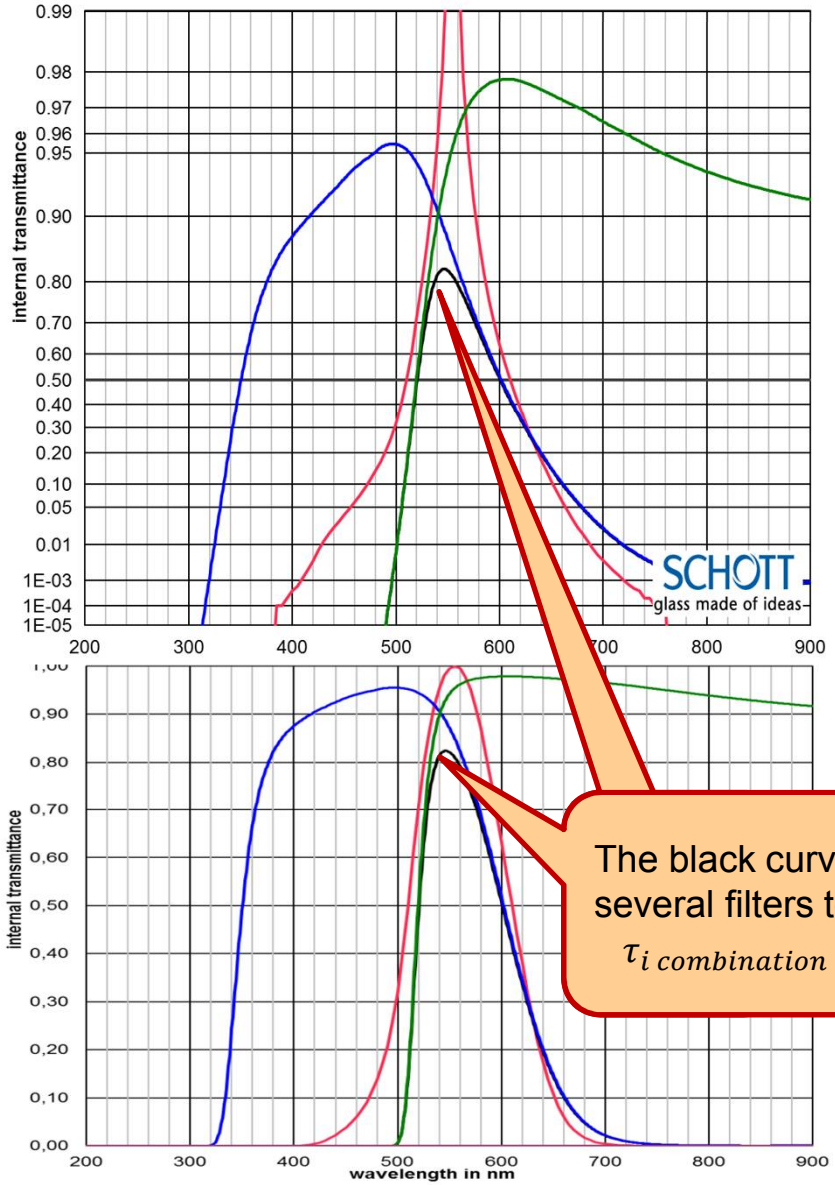
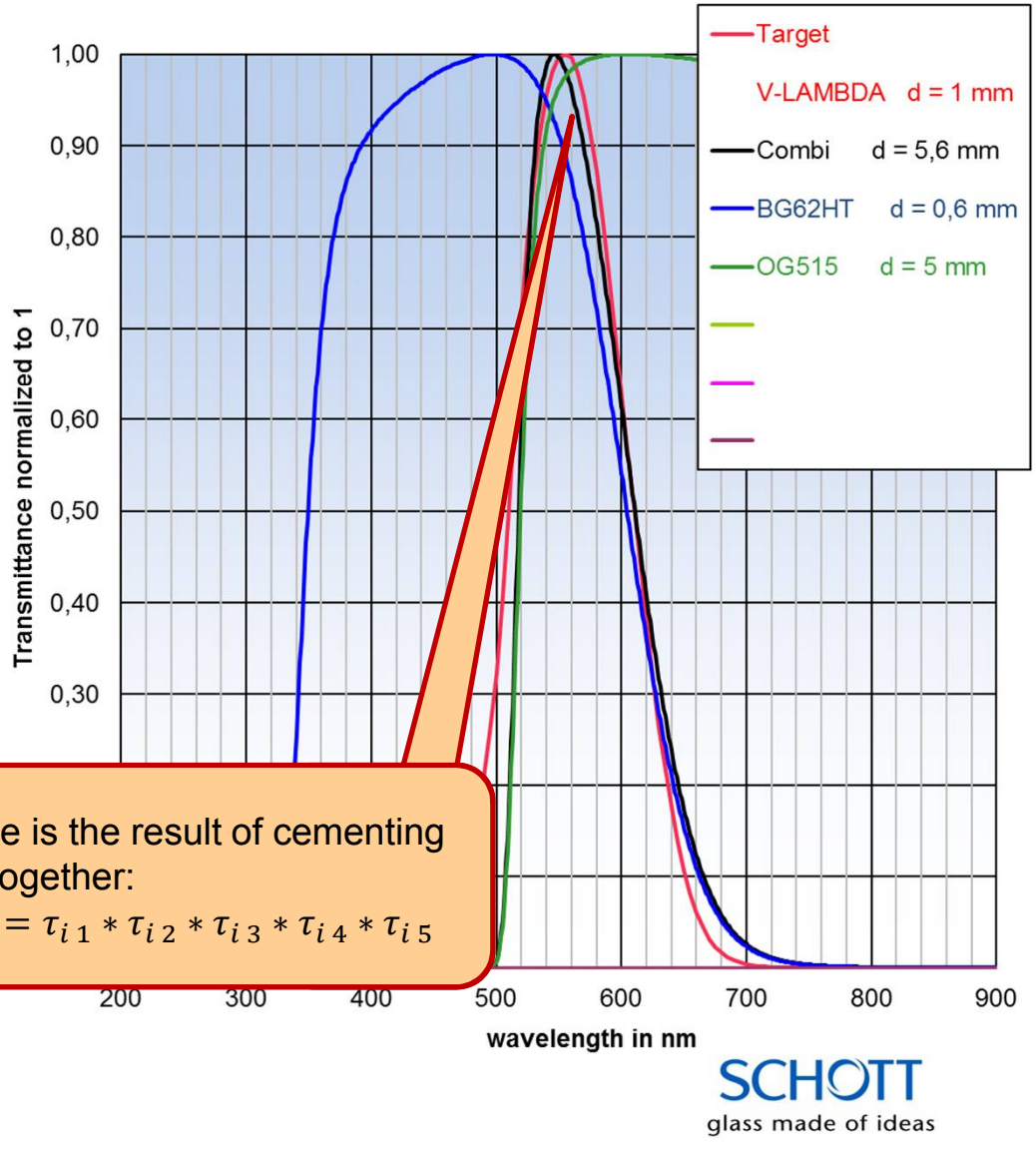
Combining filters:
internal transmittance in diabatic, linear, normalized scale





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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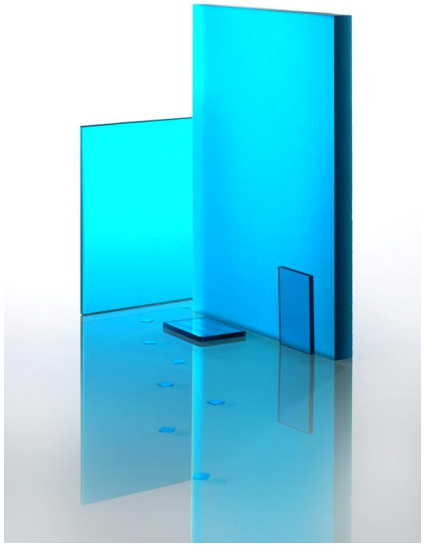
5. Tabulated data

6. User defined filters and light sources



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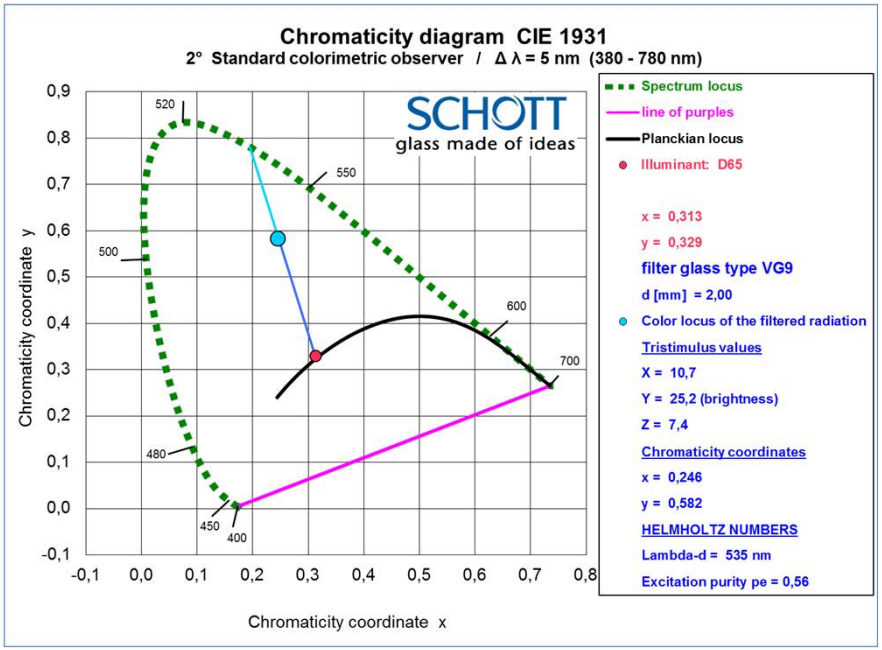
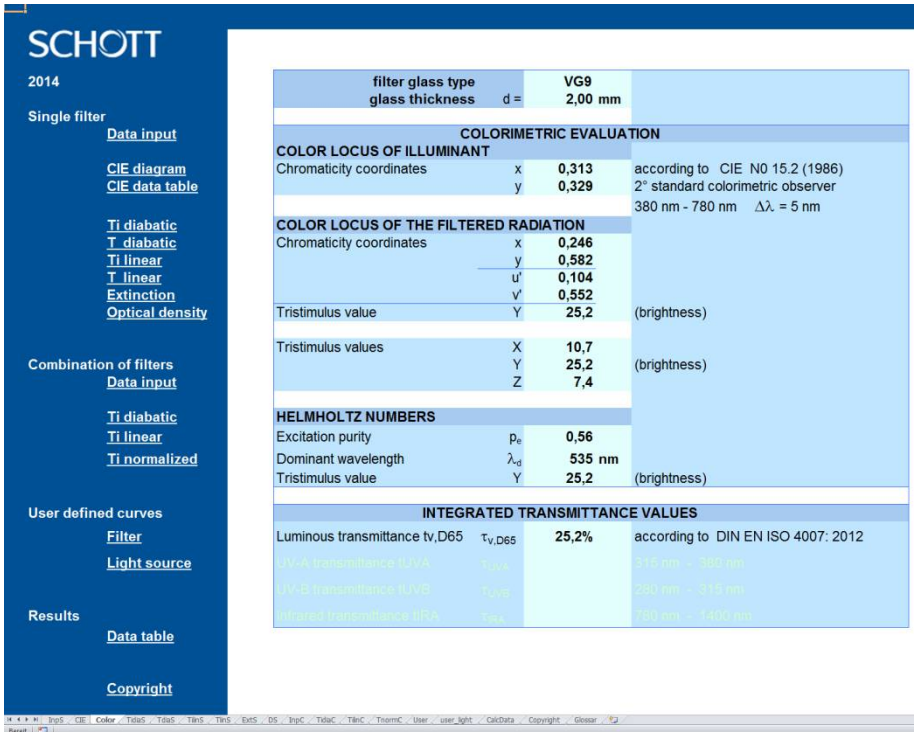
Color of light source and filtered radiation

- 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





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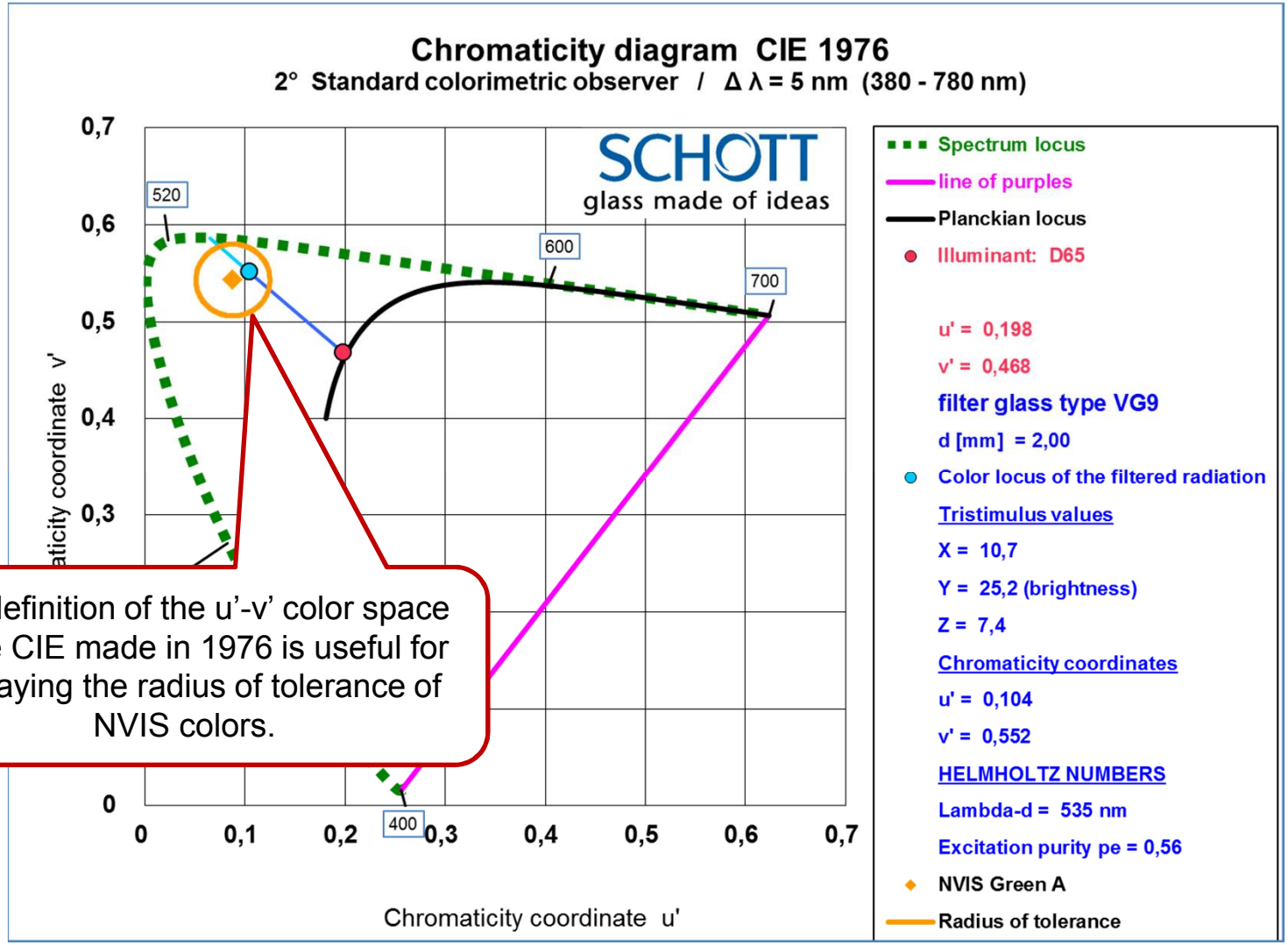
Color of filtered radiation in u'-v'-coordinates



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.

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The internal transmittance data is listed for the specified thicknesses

- The sheet „CalcData“ 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
Ti linear
Ti normalized
User defined curves
Data input
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	**UG5**	**UG1**	**UG5**	**UG11**	**BG64**	**Ti=1**	**RG780**	**Combi**
	Reflection factor P	0,910	0,910	0,910	0,910	0,916	1,000	0,910	0,920
	Reference thickness	1,00	1,00	1,00	1,00	1,00	1,00	3,00	----
	Filter thickness d	**2,000**	**1,000**	**0,900**	**1,200**	**1,000**	**0,000**	**0,000**	**3,100**
	λ[nm]	τ_i	τ_i Target	τ_i 1	τ_i 2	τ_i 3	τ_i 4	τ_i 5	τ_i combination
	200	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	201	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	202	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	203	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	204	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	205	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	206	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	207	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	208	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	209	1,00E-10	1,00E-12	3,16E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,16E-19
	210	4,99E-10	1,00E-12	6,52E-05	1,00E-06	1,00E-08	1,00E+00	1,00E+00	6,52E-19
	211	8,47E-09	1,00E-12	2,33E-04	1,00E-06	1,00E-08	1,00E+00	1,00E+00	2,33E-18
	212	9,91E-08	1,00E-12	7,05E-04	1,00E-06	1,00E-08	1,00E+00	1,00E+00	7,05E-18
	213	6,67E-07	1,00E-12	1,66E-03	1,00E-06	1,00E-08	1,00E+00	1,00E+00	1,66E-17
	214	4,00E-06	1,00E-12	3,72E-03	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,72E-17
	215	2,04E-05	1,00E-12	7,75E-03	1,00E-06	1,00E-08	1,00E+00	1,00E+00	7,75E-17
	216	1,19E-04	1,00E-12	1,71E-02	1,00E-06	1,00E-08	1,00E+00	1,00E+00	1,71E-16
	217	4,37E-04	1,00E-12	3,08E-02	1,00E-06	1,00E-08	1,00E+00	1,00E+00	3,08E-16
	218	1,12E-03	1,00E-12	4,70E-02	1,00E-06	1,00E-08	1,00E+00	1,00E+00	4,70E-16
	219	2,28E-03	1,00E-12	6,47E-02	1,00E-06	1,00E-08	1,00E+00	1,00E+00	6,47E-16
	220	4,76E-03	1,00E-12	9,01E-02	1,00E-06	1,00E-08	1,00E+00	1,00E+00	9,01E-16
	221	8,97E-03	1,00E-12	1,20E-01	1,00E-06	1,00E-08	1,00E+00	1,00E+00	1,20E-15
	222	1,64E-02	1,00E-12	1,57E-01	1,00E-06	1,00E-08	1,00E+00	1,00E+00	1,57E-15
	223	2,72E-02	1,00E-12	1,98E-01	1,00E-06	1,00E-08	1,00E+00	1,00E+00	1,98E-15
	224	4,15E-02	1,00E-12	2,39E-01	1,00E-06	1,00E-08	1,00E+00	1,00E+00	2,39E-15

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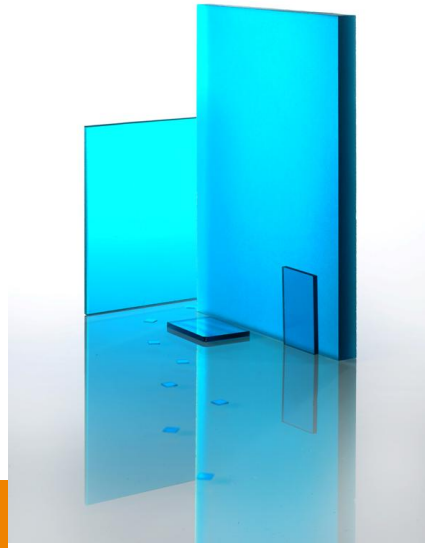
6. User defined filters and light sources



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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
Ti linear
Ti normalized
User defined curves
Filter
Light source
Results
Data table
Copyright

User type name	V-LAMBDA	Mycurve	upper limit	linear				
Reflection factor P	1,00	0,90	0,90	0,90				
Reference thickness in mm	1,00	2,00	1,00	1,00				
Free for text and notes	380 - 780 nm	Example	Example	Example				
λ[nm]	τ_i 01	τ_i 02	τ_i 03	τ_i 04	τ_i 05	τ_i 06	τ_i 07	τ_i 08
200		0,001						
201		0,001		0,15075				
202		0,001		0,1515				
203		0,001		0,15225				
204		0,001		0,153				
205		0,001		0,15375				
206		0,001		0,1545				
207		0,001		0,15525				
208		0,001		0,156				
209		0,001		0,15675				
210		0,001		0,1575				
211		0,001		0,15825				
212		0,001		0,159				
213		0,001		0,15975				
214		0,001		0,1605				
215		0,001		0,16125				
216		0,001		0,162				
217		0,001		0,16275				
218		0,001		0,1635				
219		0,001		0,16425				
220		0,001		0,165				
221		0,001		0,16575				
222		0,001		0,1665				
223		0,001		0,16725				
224		0,001		0,168				
225		0,001		0,16875				
226		0,001		0,1695				
227		0,001		0,17025				
228		0,001		0,171				

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.

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Single filter
Data input
CIE diagram
CIE data table
Ti diabatic
T diabatic
Ti linear
T linear
Extinction
Optical density

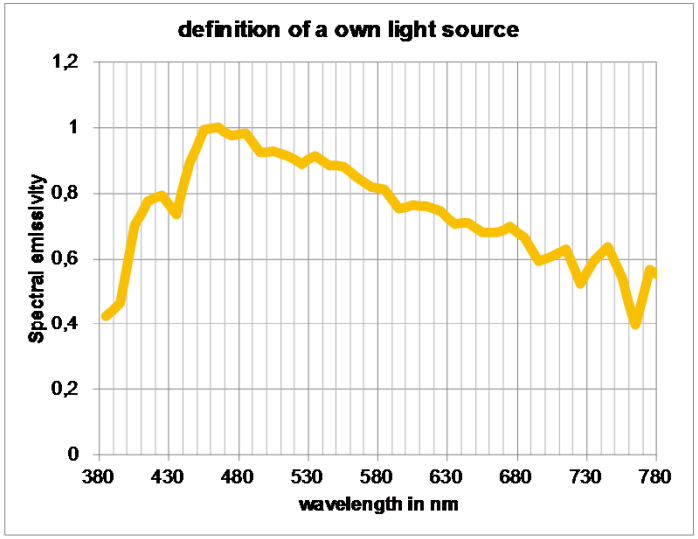
Combination of filters
Data input
Ti diabatic
Ti linear
Ti normalized

User defined curves
Filter
Light source

Results
Data table
Copyright

definition of a own light source

wavelength in nm	you may define the spectral emissivity of your own light source in steps of 5 nm
380	0,424448217
385	0,443972835
390	0,463497453
395	0,583191851
400	0,702886248
405	0,739388795
410	0,776740238
415	0,785229202
420	0,79286927
425	0,764855688
430	0,735993209
435	0,813242784
440	0,89049236
445	0,941426146
450	0,993208829
455	0,996604414
460	1
465	0,987266553
470	0,975382003
475	0,979626486
480	0,983870968
485	0,954159593
490	0,923599321
495	0,92614601
500	0,928692699
505	0,921901528
510	0,915110357
515	0,90237691
520	0,889643463
525	0,901528014



Addendum

- Any comments or suggestions are welcome.
- If you have any questions or recommendations please contact your local sales representative.