Fraunhofer-Institut für Optronik,
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Spectral Measurement of Infrared Cameras: Description of the Equipment Used

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1. MEASUREMENT SET-UP AND METHOD

Figure 1 shows the principle set-up of the IOSB spectral measurement equipment. It is based on a gold covered integrating sphere of approximately 30 cm diameter and a filter wheel with 48 spectral filters in the range of 1.5 µm to 14 µm (Table 1).

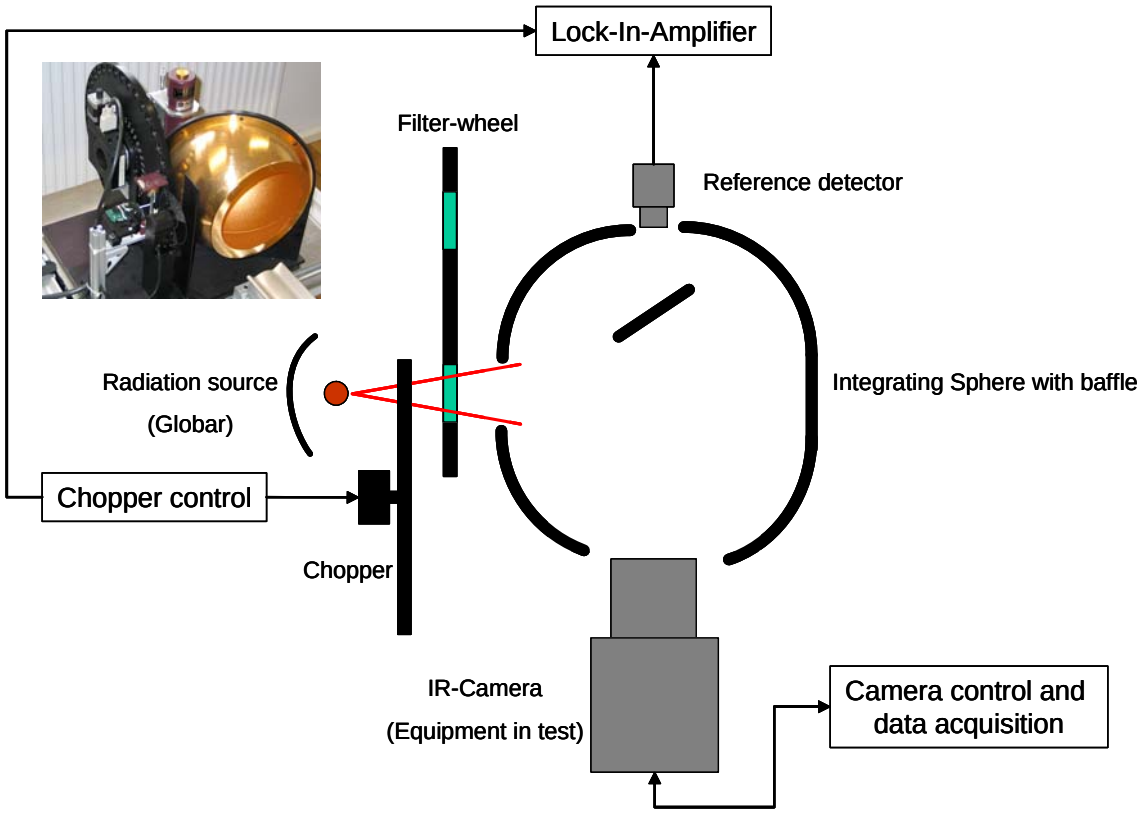


Figure 1: Schematic set-up of the spectral measurement equipment. The inlaid image shows a photo of the real assembly.

Wavelength range	Number of filters	Full width at half maximum	Transmission
1.5 µm to 1.9 µm	3	0.2 µm	> 45%
2.0 µm to 5.5 µm	18	0.2 µm	> 60%
5.7 µm to 12 µm	22	0.3 µm	> 55%
12.2 µm to 14 µm	5	0.4 µm	> 45%

Table 1: General characteristics of the filters used in the spectral measurement equipment.

As radiation source, a globar with a temperature of approximately 1000 K is used. Its radiation is first modulated by a chopper, then going through the selected spectral filter into the integrating sphere. By multiple reflections, a homogeneous radiation is achieved on the openings for equipment in test and reference detector. As equipment in test and reference detector is positioned direct opposite each other, a baffle is shielding them from seeing each other. An HgCdTe-single-element detector with known spectral behaviour is used as reference detector. Its voltage is measured by using a lock-in amplifier. The signal of the equipment in test has to be recorded by using an analogous or digital frame grabber. This recording is done unsynchronised to the chopper. The analysis of the camera data is done by

calculating the amplitude of the modulated signal at the copper frequency. From this amplitude signal, the voltage of the reference detector and the known spectral behaviour of the reference detector the spectral response of the equipment in test can be calculated according to

$$R_C(\lambda) \sim \frac{S_C(\lambda)}{S_R(\lambda)} \cdot R_R(\lambda) \qquad (1.1)$$

$R_C(\lambda)$: Responsivity of the camera at wavelength λ.
$R_R(\lambda)$: Responsivity of the reference detector at wavelength λ.
$S_C(\lambda)$: Signal of the camera at wavelength λ.
$S_R(\lambda)$: Signal of the reference detector at wavelength λ.

The actual components used for the measurements are summarized in detail in Table 2.

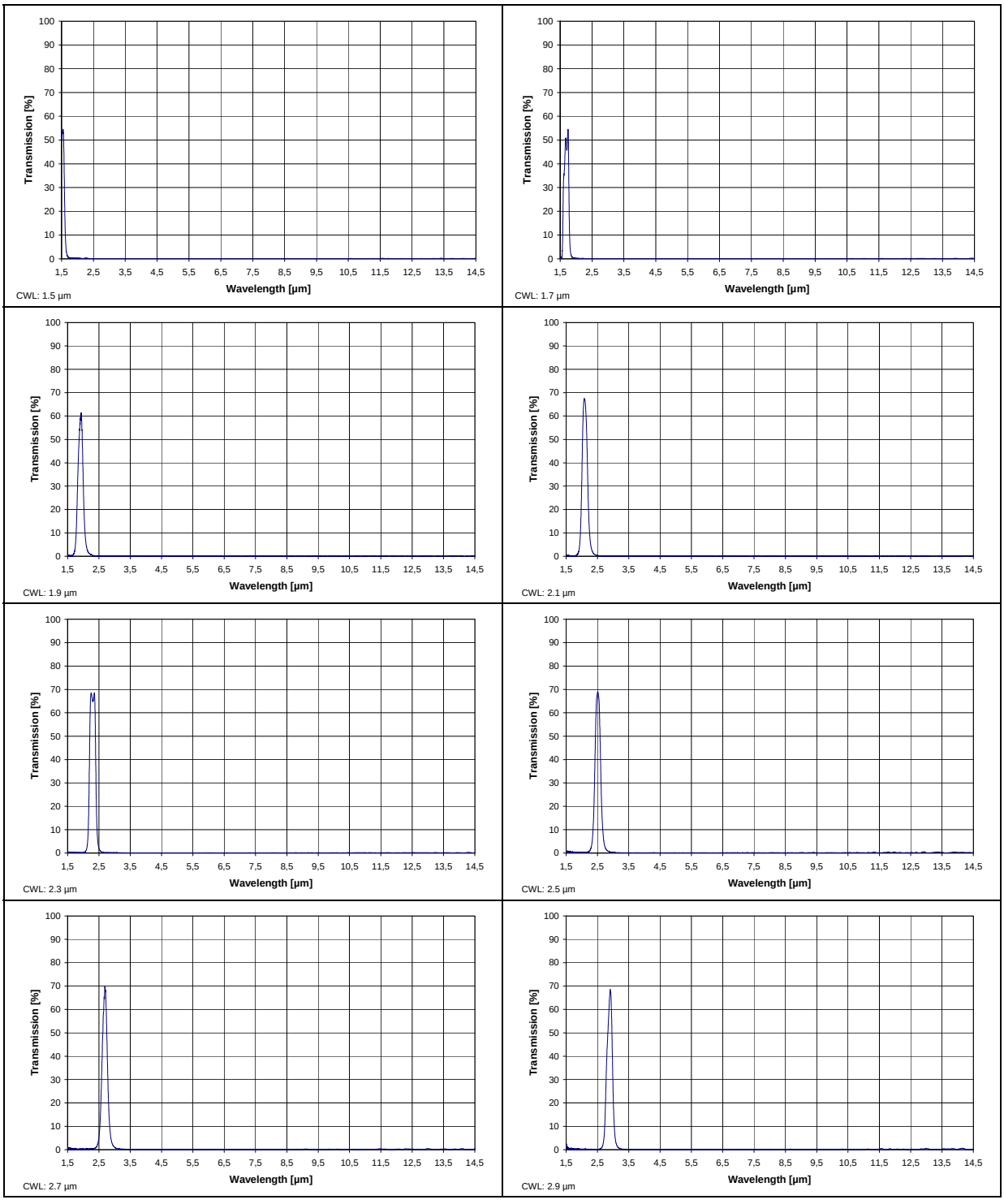
Component	Equipment used
Globar	Oriel Instruments IR Element Model 6363 Oriel Instruments IR/QTH Power Supply Model 68938
Chopper	New Focus, Inc. Model 3501 optical Chopper
Filter	Northumbrian Optical Coatings Ltd. Spectral transmission according to Annex 1.
Integrating Sphere	Labsphere, Infragold coated
Reference Detector	Electro Optical Systems Inc. Cryogenic Receiver Module Model No. MCT10-020-E-LN6N Serial No. 120310 Spectral response according to Annex 2
Lock-In Amplifier	Stanford Research Systems Model SR830 DSP Lock-In Amplifier

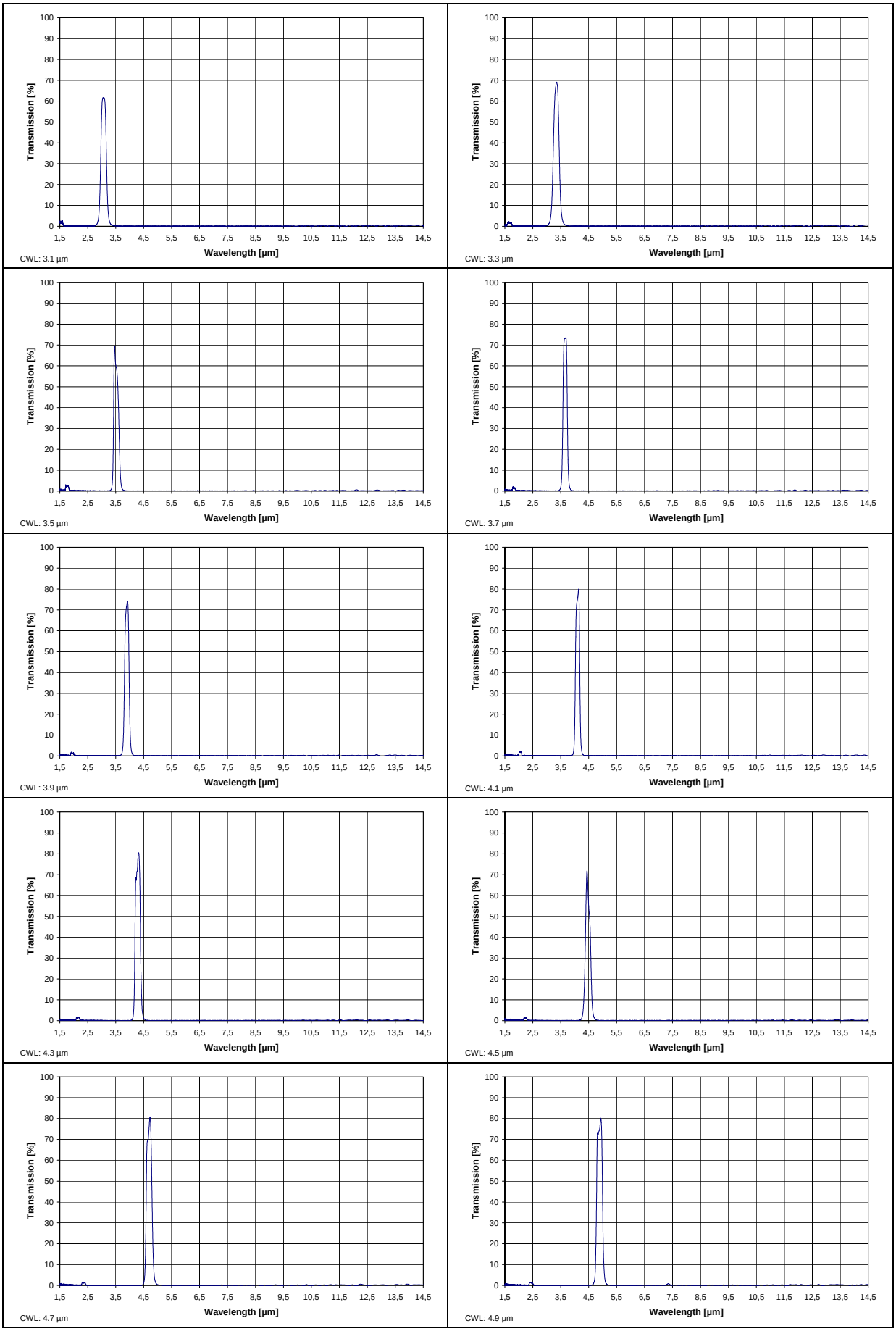
Table 2: Components used for the spectral measurements.

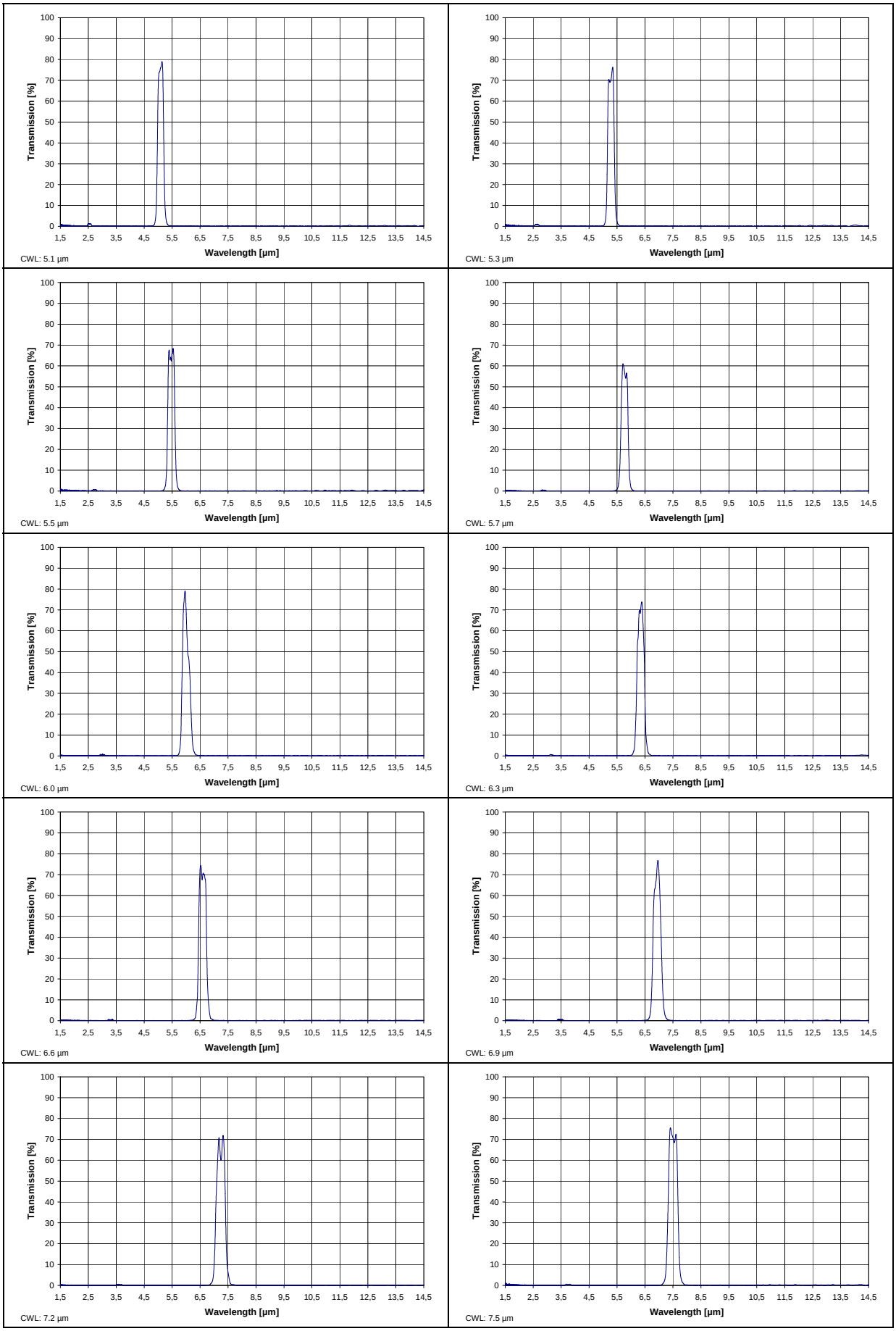
ANNEX A1:

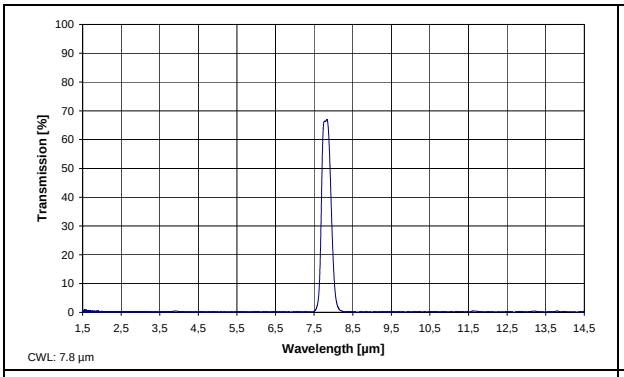
Spectral Transmission of the Filters used

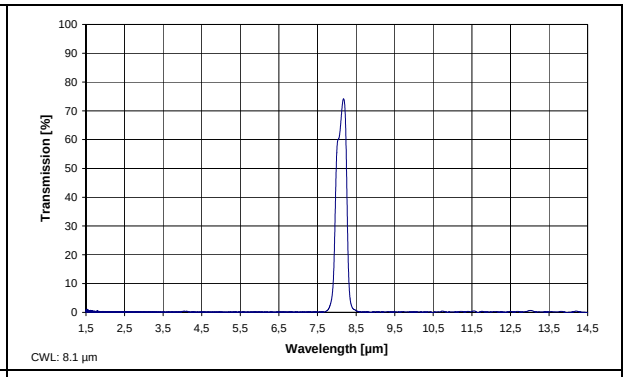
Presented here are the spectral transmission curves of the filters used in the spectral measurement equipment. They were measured by Fraunhofer IOSB with a BRUKER IFS 66/S Fourier Spectrometer in the spectral range from 1.5 µm to 20 µm (displayed here only from 1.5 µm to 14.5 µm). Original measurement curves of November 28th, 2000 and July 12th, 2006, supplied with the filters from Northumbrian Optical Coatings Limited, are available at IOSB. They are limited in spectral range and cover only approximately ± 2 µm around the central wavelength of the filter.

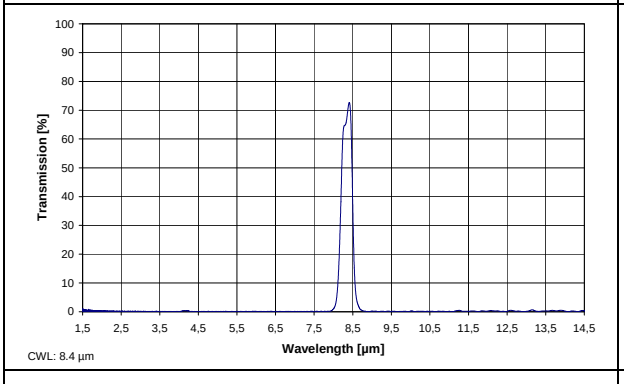


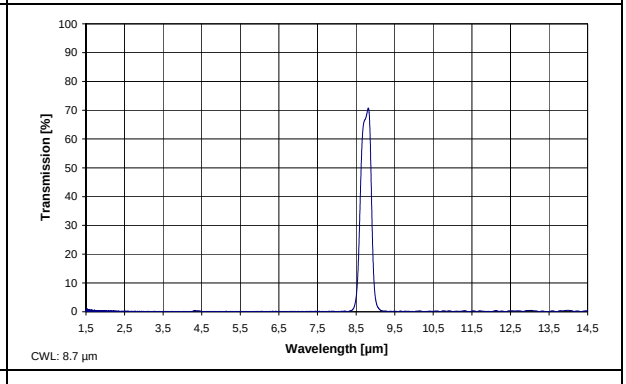

Transmission [%]
Wavelength [µm]
CWL: 3.1 µm
CWL: 3.3 µm
CWL: 3.5 µm
CWL: 3.7 µm
CWL: 3.9 µm
CWL: 4.1 µm
CWL: 4.3 µm
CWL: 4.5 µm
CWL: 4.7 µm
CWL: 4.9 µm

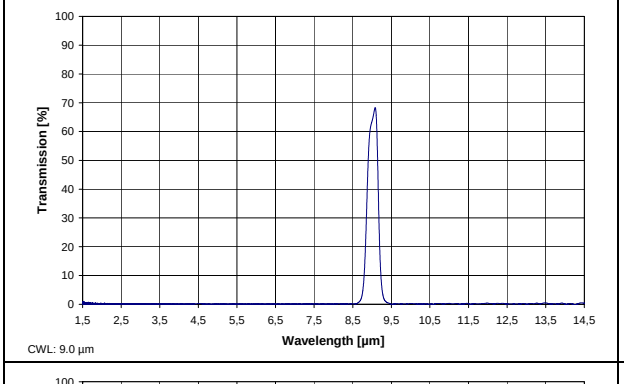

Transmission [%]
Wavelength [µm]
CWL: 5.1 µm
CWL: 5.3 µm
CWL: 5.5 µm
CWL: 5.7 µm
CWL: 6.0 µm
CWL: 6.3 µm
CWL: 6.6 µm
CWL: 6.9 µm
CWL: 7.2 µm
CWL: 7.5 µm

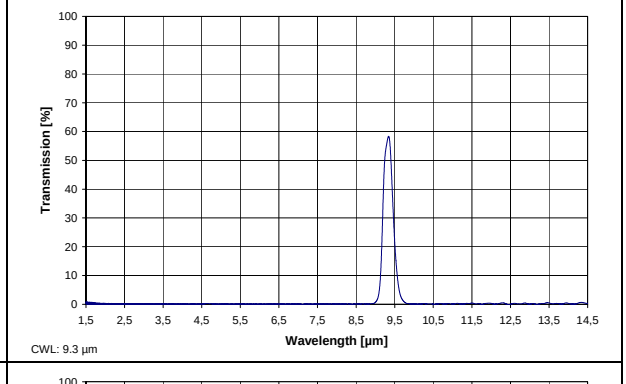

Transmission [%]
Wavelength [µm]
CWL: 7.8 µm

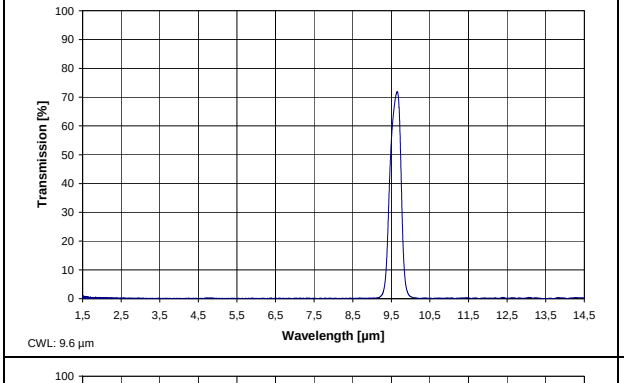

Transmission [%]
Wavelength [µm]
CWL: 8.1 µm

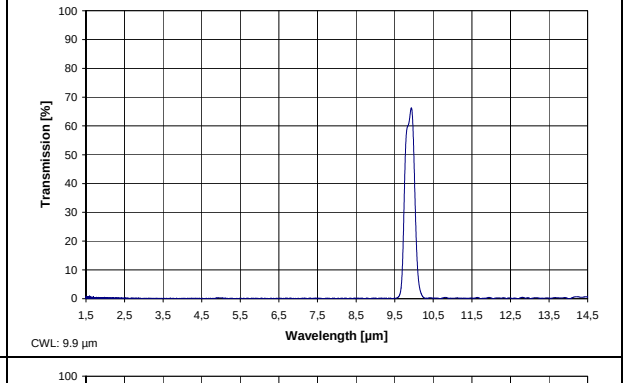

Transmission [%]
Wavelength [µm]
CWL: 8.4 µm

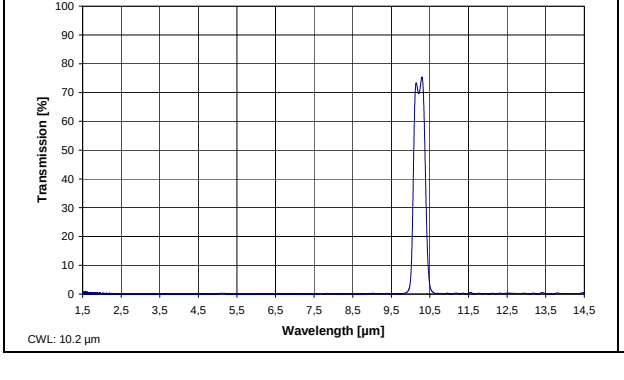

Transmission [%]
Wavelength [µm]
CWL: 8.7 µm

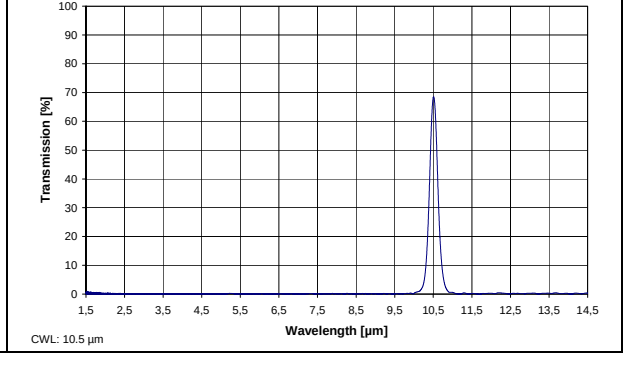

Transmission [%]
Wavelength [µm]
CWL: 9.0 µm

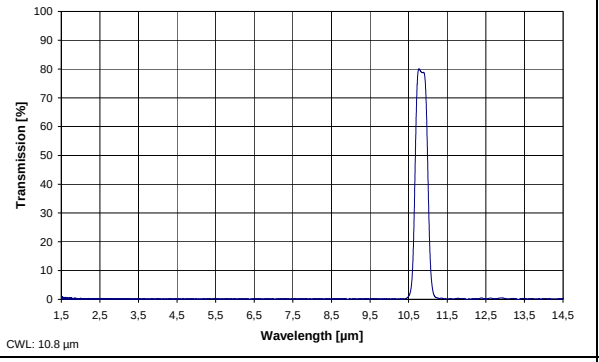

Transmission [%]
Wavelength [µm]
CWL: 9.3 µm

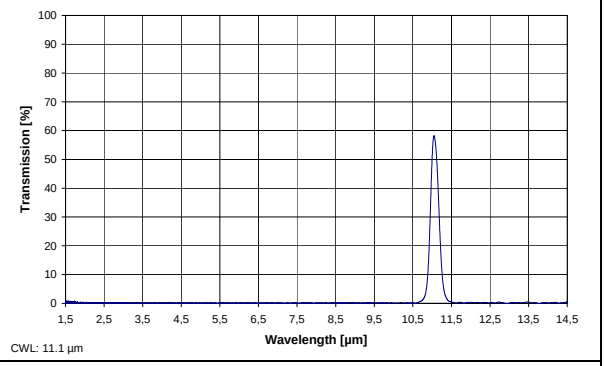

Transmission [%]
Wavelength [µm]
CWL: 9.6 µm

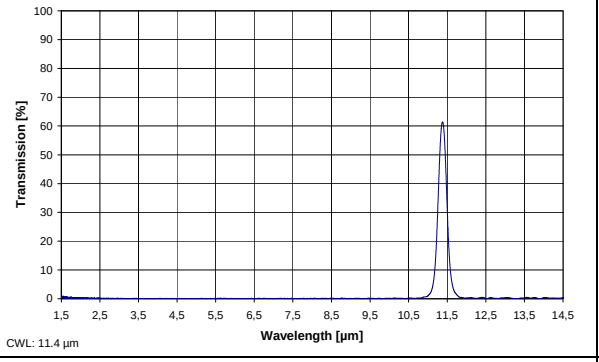

Transmission [%]
Wavelength [µm]
CWL: 9.9 µm

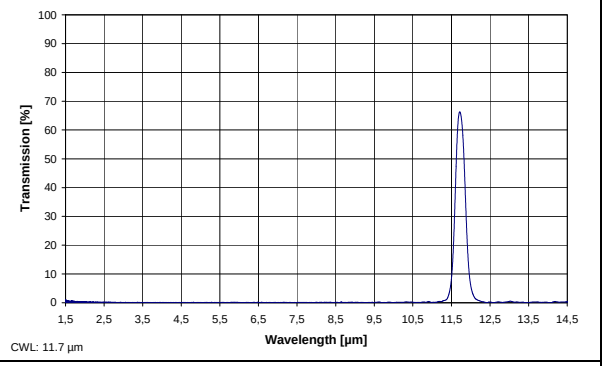

Transmission [%]
Wavelength [µm]
CWL: 10.2 µm

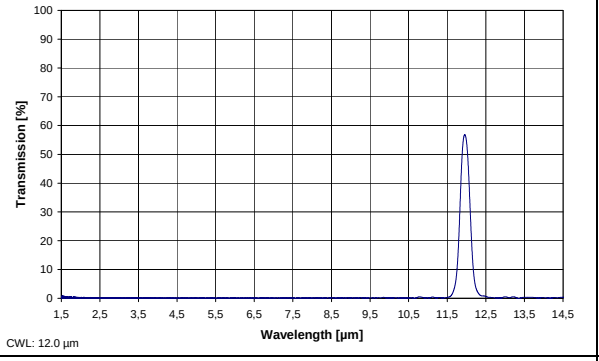

Transmission [%]
Wavelength [µm]
CWL: 10.5 µm

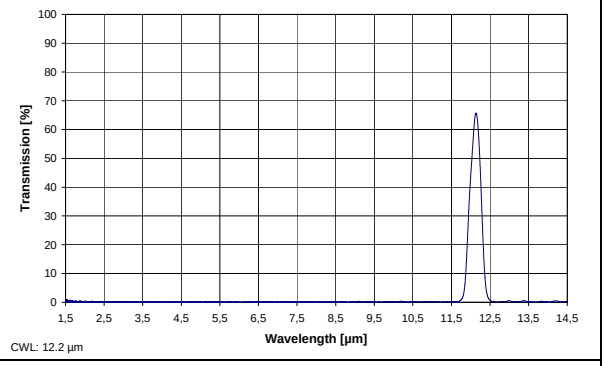

Transmission [%]
Wavelength [µm]
CWL: 10.8 µm

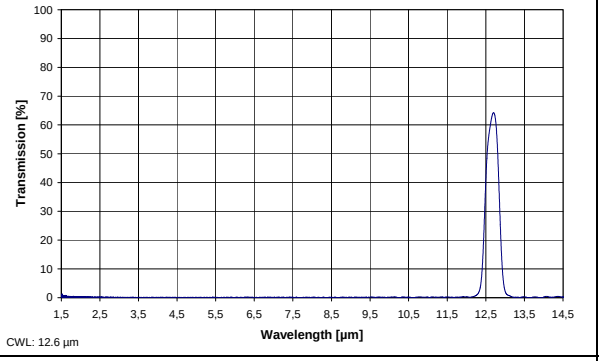

Transmission [%]
Wavelength [µm]
CWL: 11.1 µm

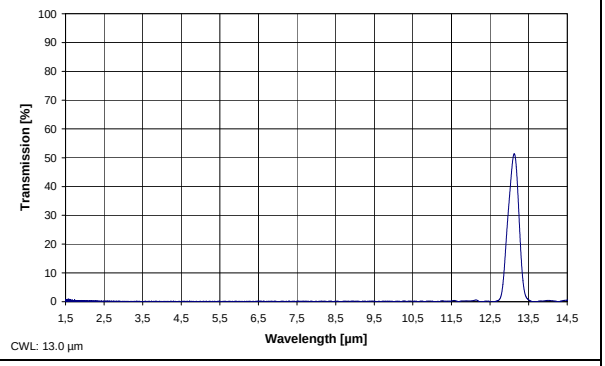

Transmission [%]
Wavelength [µm]
CWL: 11.4 µm

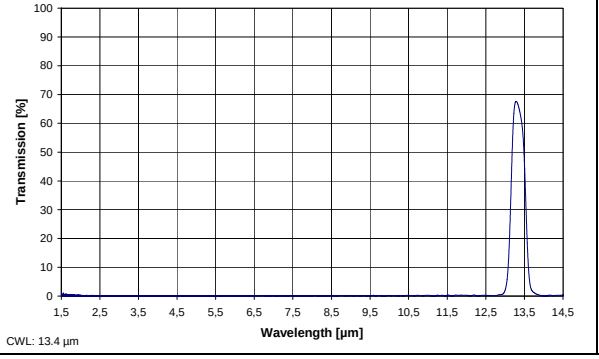

Transmission [%]
Wavelength [µm]
CWL: 11.7 µm

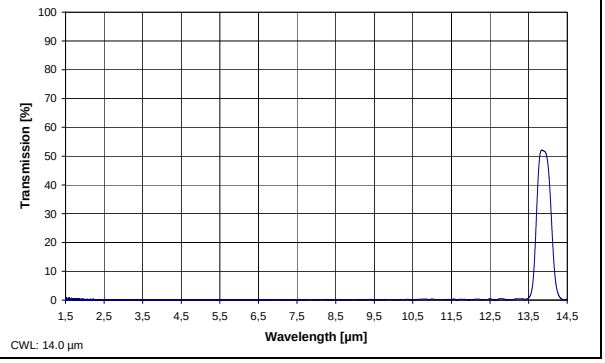

Transmission [%]
Wavelength [µm]
CWL: 12.0 µm


Transmission [%]
Wavelength [µm]
CWL: 12.2 µm


Transmission [%]
Wavelength [µm]
CWL: 12.6 µm


Transmission [%]
Wavelength [µm]
CWL: 13.0 µm


Transmission [%]
Wavelength [µm]
CWL: 13.4 µm


Transmission [%]
Wavelength [µm]
CWL: 14.0 µm

ANNEX A2:

Spectral Response of the Reference Detector Electro-Optical Systems Inc. MCT10-020-E-LN6N

The graph in Figure A2.1 shows the normalised spectral response of the reference detector according to the data supplied by the manufacturer in December 2003. For the analyses of the measurements, the spectral response was averaged according to the central wavelength and the full width at half maximum of the filters. The resulting values are also plotted within the graph.

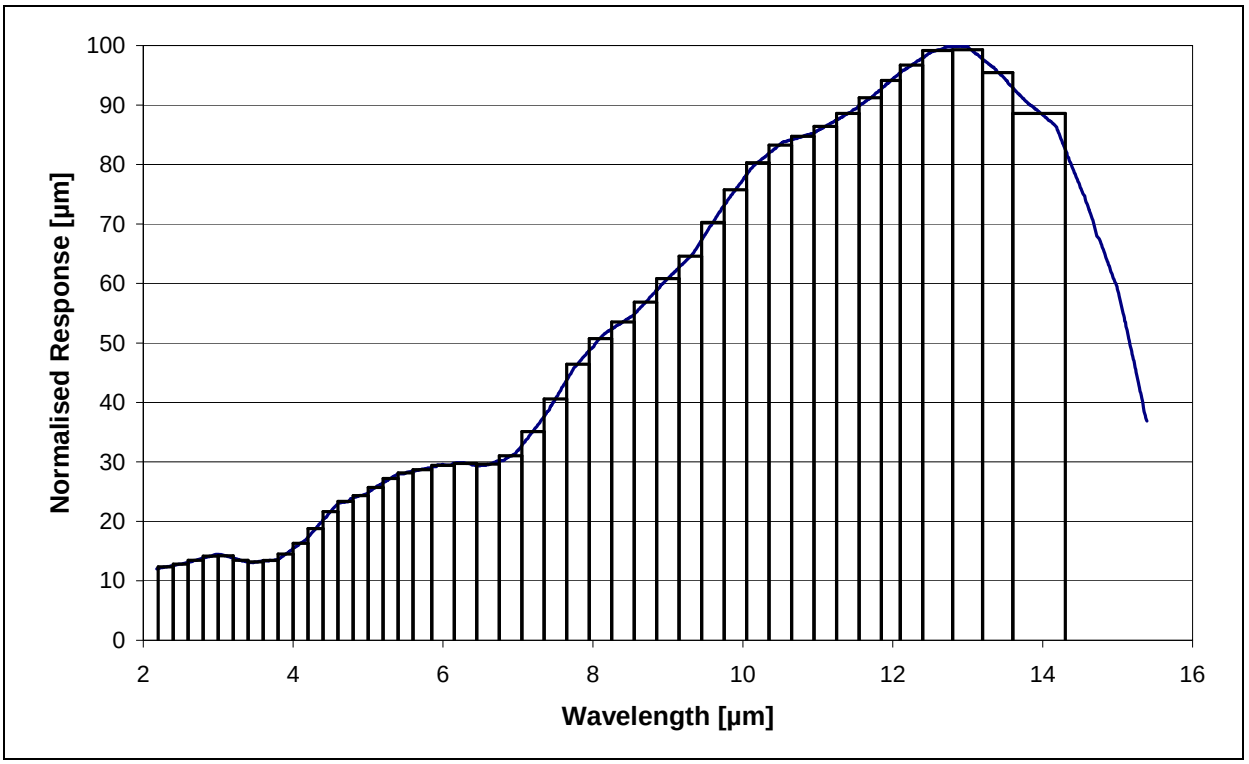


Figure A2.1: Normalised spectral response of the reference detector (blue line) according to the data supplied by the manufacturer in December 2003 and approximation according to the spectral ranges of the filters (black rectangles).