ASTRONOMICAL FILTERS SPECTRAL TRANSMISSION

Summary

Special thanks to COSMODIff, 3 rue Romiguières, 31000 Toulouse (France), which provided us some filters of this performances evaluation.

Remerciement spécial à COSMODIff, 3 rue Romiguières, 31000 Toulouse (France), qui a fourni quelques-uns des filtres de cette évaluation de performances.

Protocol. The filters transmission of this page are acquired with a LISA spectrograph and a modified Canon 350D as detector (the internal IR cut filter of this DSLR is removed). The spectral density of the light source (halogen lamp), the efficiency of the spectrograph and of the detector are taken into account for construct the true relative transmission curve. A neon lamp and a mercury lamp are used for spectral calibration. The spectra are processed with VisualSpec.

The effective aperture number of the optical beam used for the measure is near f/8 (limited by the acceptance angle of the spectrograph) and except some situations, the beam axis is normal to the filter surfaces. This beam is assimilable to a collimated beam (slow converging).

The passband of the filter is depend on the angle of incidence of light. Here some comment about this angular dependence...

If the filter is tilted by an angle α in a collimated beam, the primary effect is a shift of peak transmittance toward shorter wavelengths. If λ is the peak wavelength at angle of incidence α, if $\lambda 0$ is the peak wavelength at 0° angle of incidence (the present measures) and if *n* is the effective refractive index of the coating, the relation between these quantities is

$$\lambda = \lambda 0 \sqrt{1 - \frac{\sin^2 \alpha}{n^2}}$$

The values *n*=1.4 and *n*=2.0 are representative of inside indice of interference filters (the exact value is determined by the coating materials used and the sequence of thin-film layers in the coating).

When interference filters are used in a converging beam (as is the case in a telescope), the new transmission curve result from the integration of the rays at all of the angles within the cone. For moderate speed systems (f/2.5 or slower), the shift in the peak wavelength can be approximately predicted from the above tilted collimated beam formula: the peak wavelength shifts is about one-half the value that it would shift in collimated light at the cone's most off-axis angle. If λm is the new "central peak wavelength" when the filter is used in the converging beam, we have the following approximate relation

$$\lambda_m = \lambda 0 \left(1 - \frac{\beta^2}{4\, n^2}\right)$$

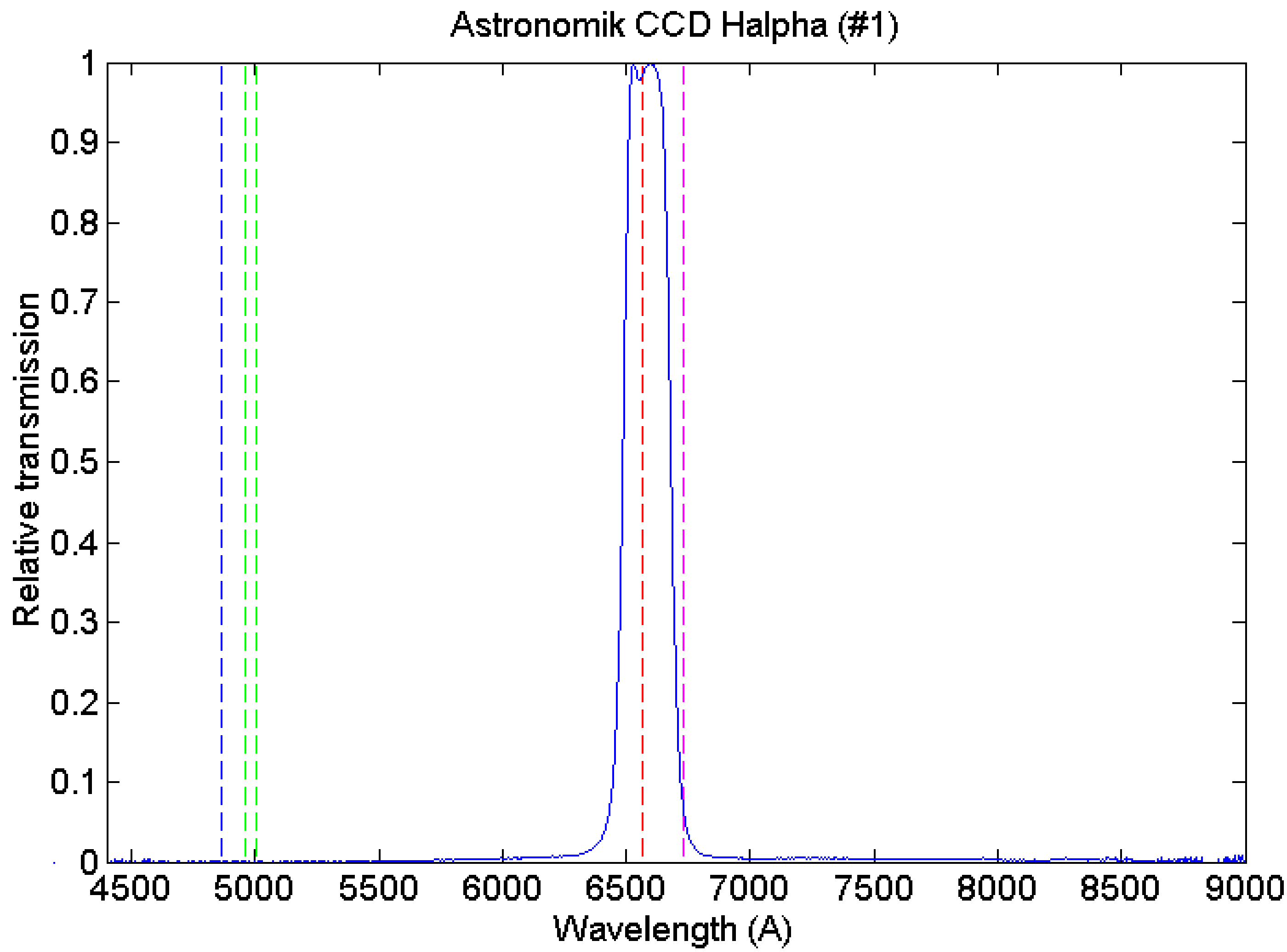
where β is the max incidence angle of light in filter, i.e. the cone angle

$$\sin \beta \approx \frac{1}{2\, No}$$

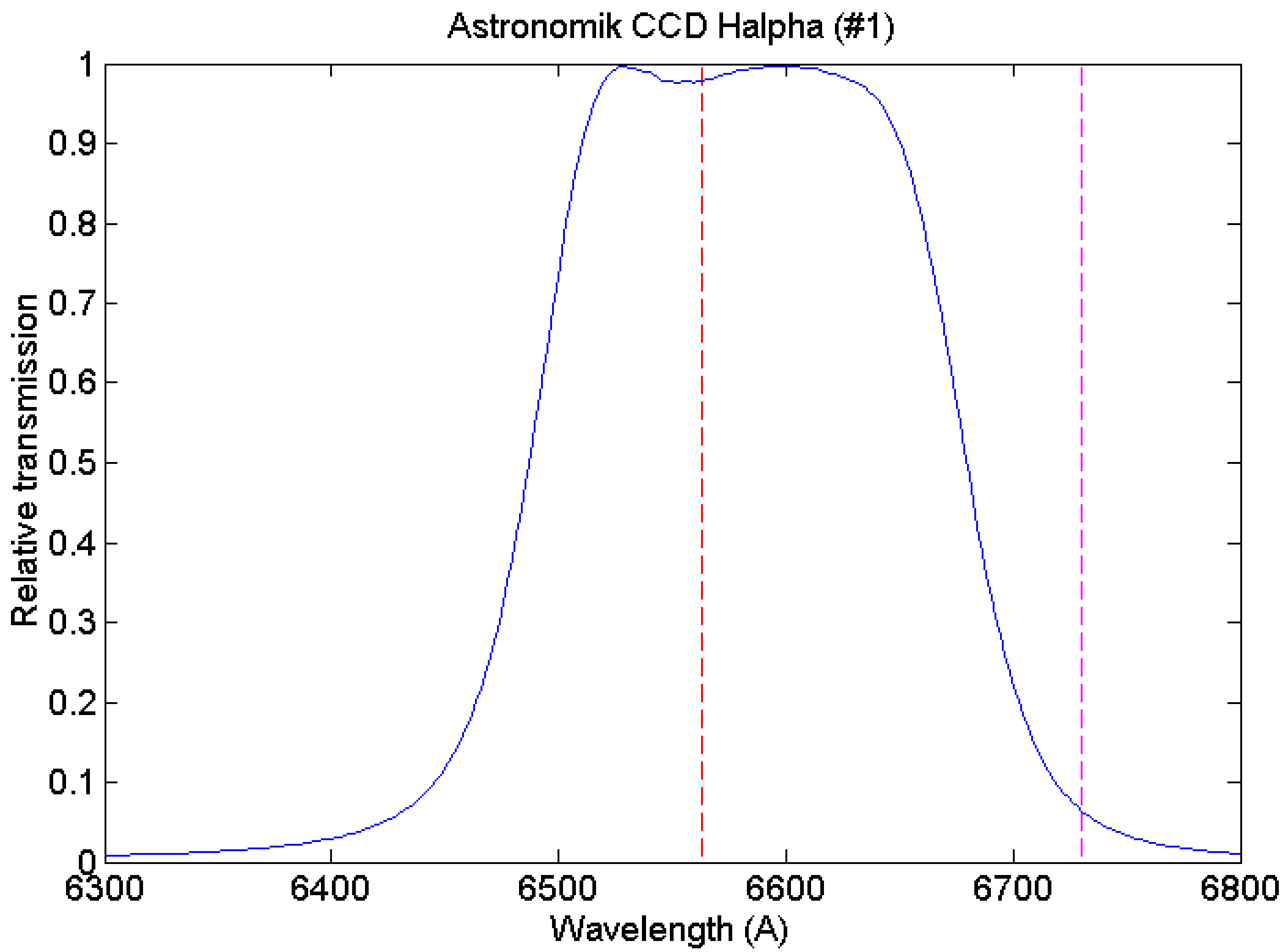
N0= aperture number of the telescope

Suppose an f/5 telescope and the Hα line (at $\lambda 0$=6563 A). Whe have *N0*=5, β=0.1 rd and λm=6559 A if *n*=2.0 and λm=6555 A if *n*=1.4.

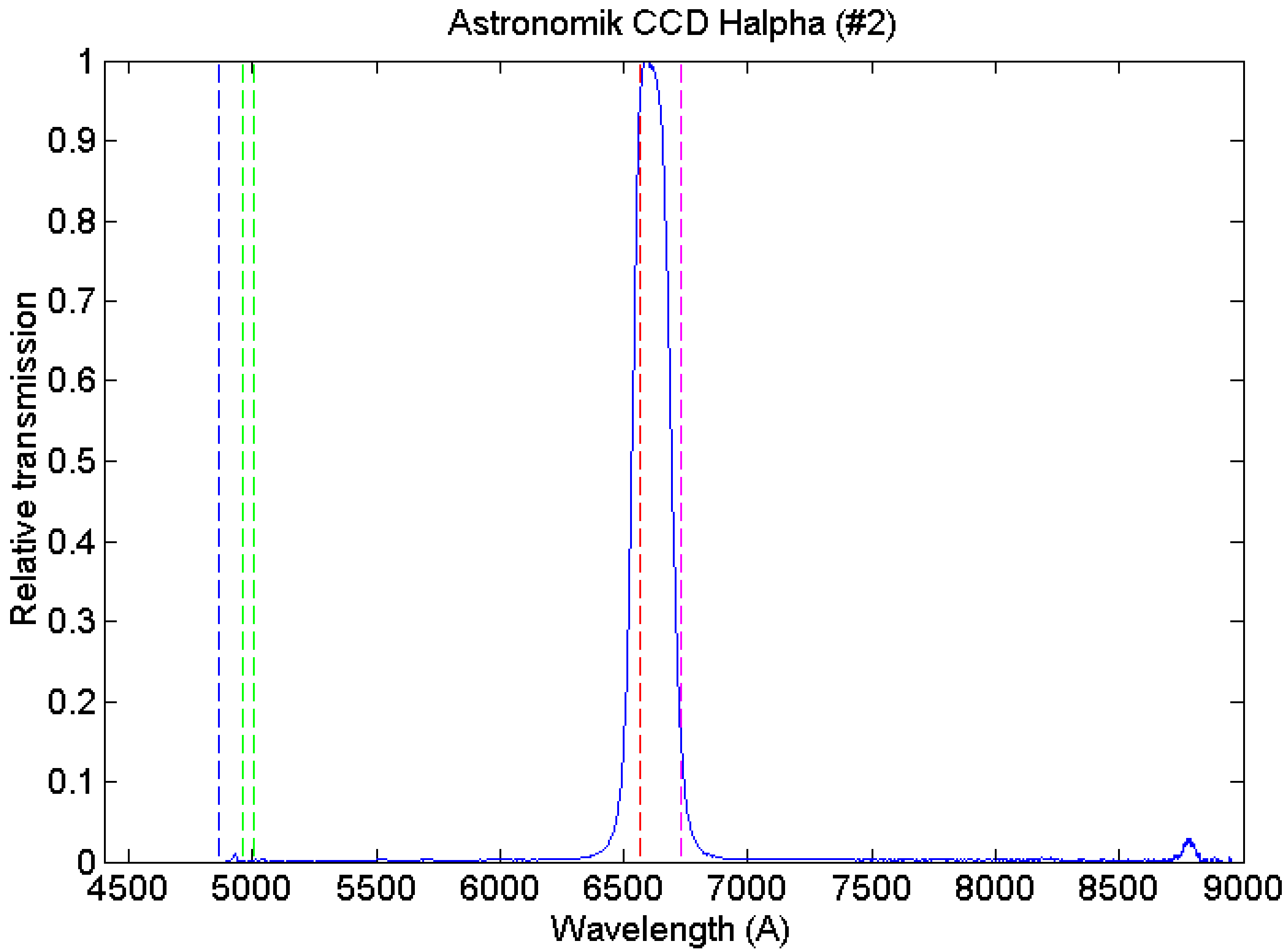
The secondary effects a the converging beam are a broadening of the transmission curve and a depression of the peak transmittance.



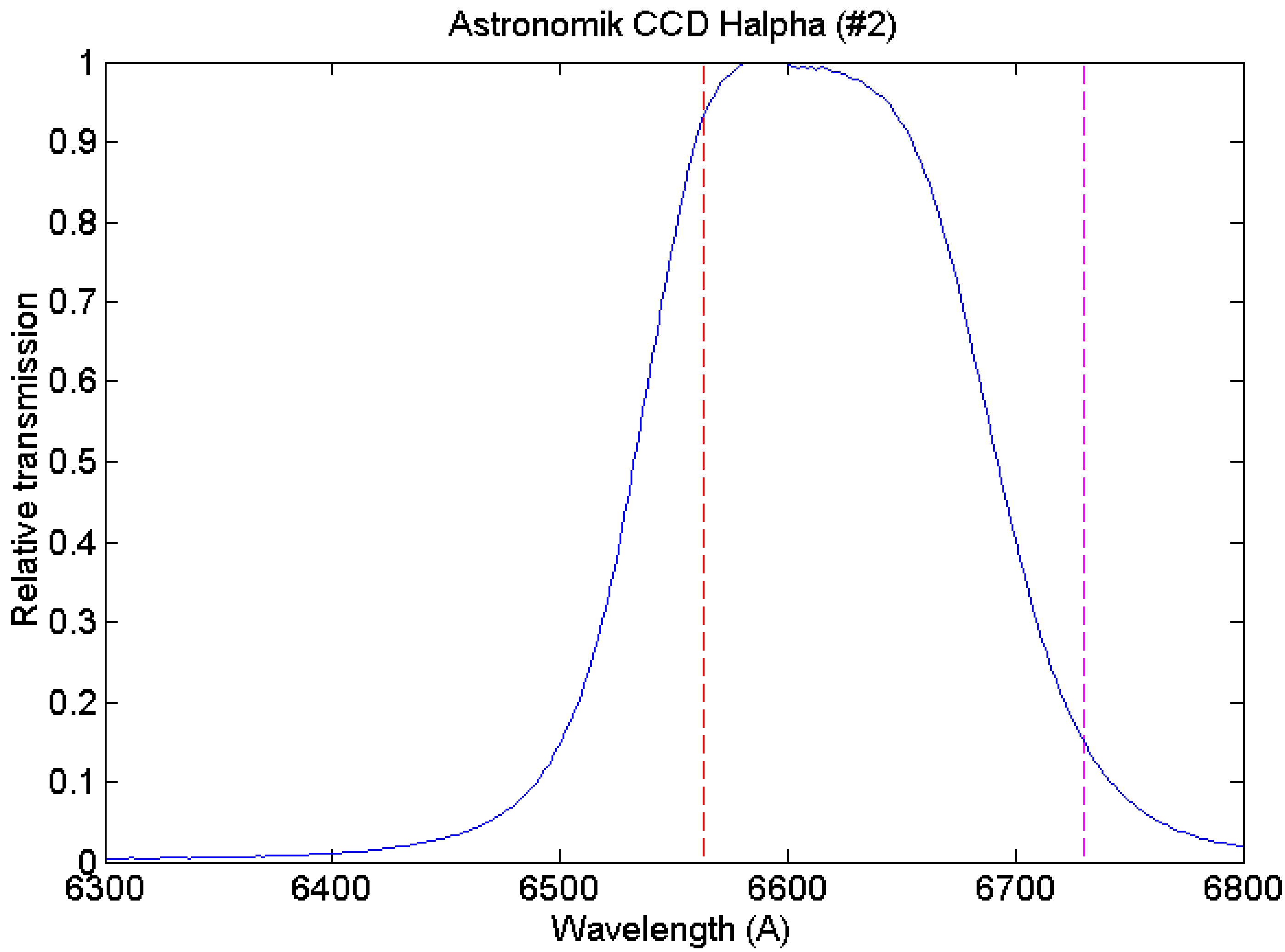
Relative transmission curve of an Astronomik CCD Hα filter (filter number 1). From left to right the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα at 6563 A (red) and [SII] line at 6730 A (cyan).



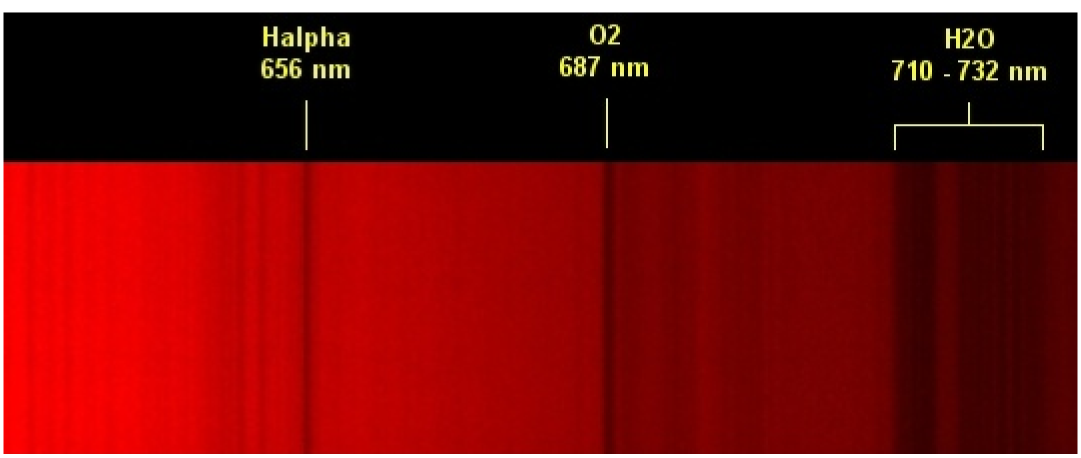
Detail of an Astronomik CCD Hα filter transmission near Halpha line (red dashed line). Filter #1

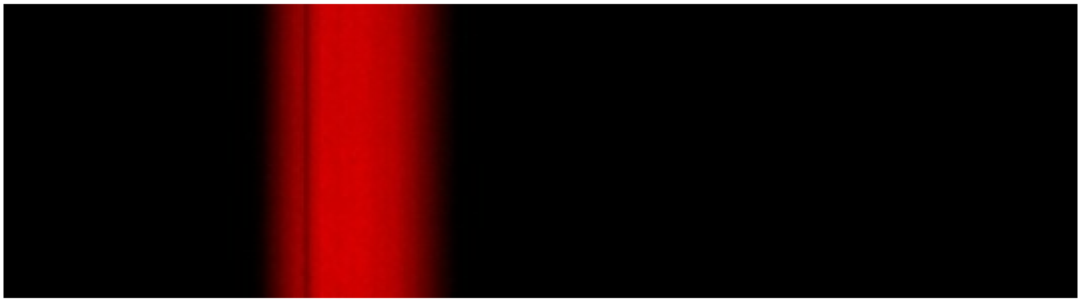


Relative transmission curve of an Astronomik CCD Hα filter (filter number 2). From left to right the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα at 6563 A (red) and [SII] doublet at 6730 A (cyan).

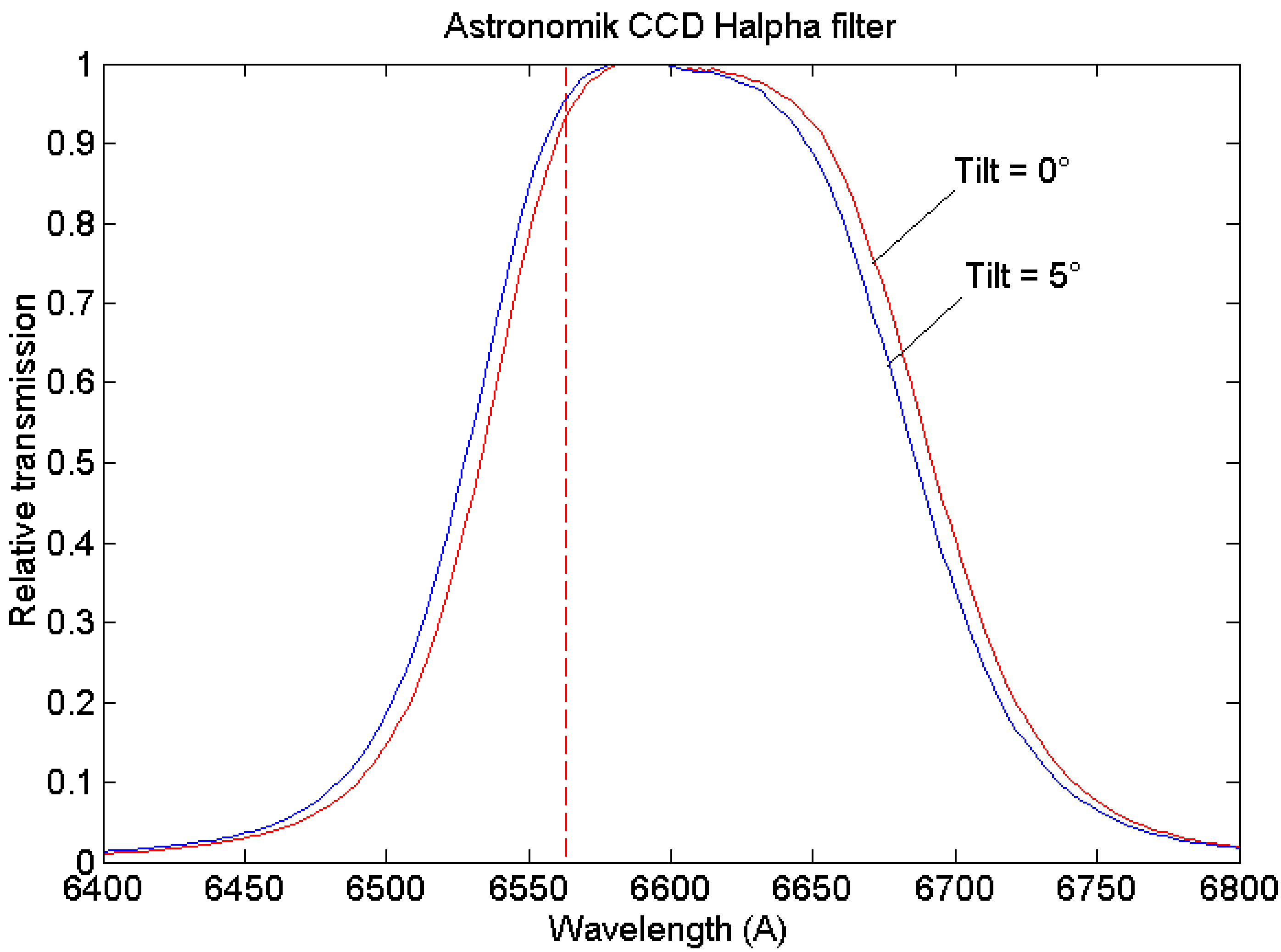


The central wavelength of the filter #2 is significantly shifted toward the bleue. Efficiency at the Halpha level is reduced by a factor 0.9 comparatively to an hypothetical correct filter. The proof...

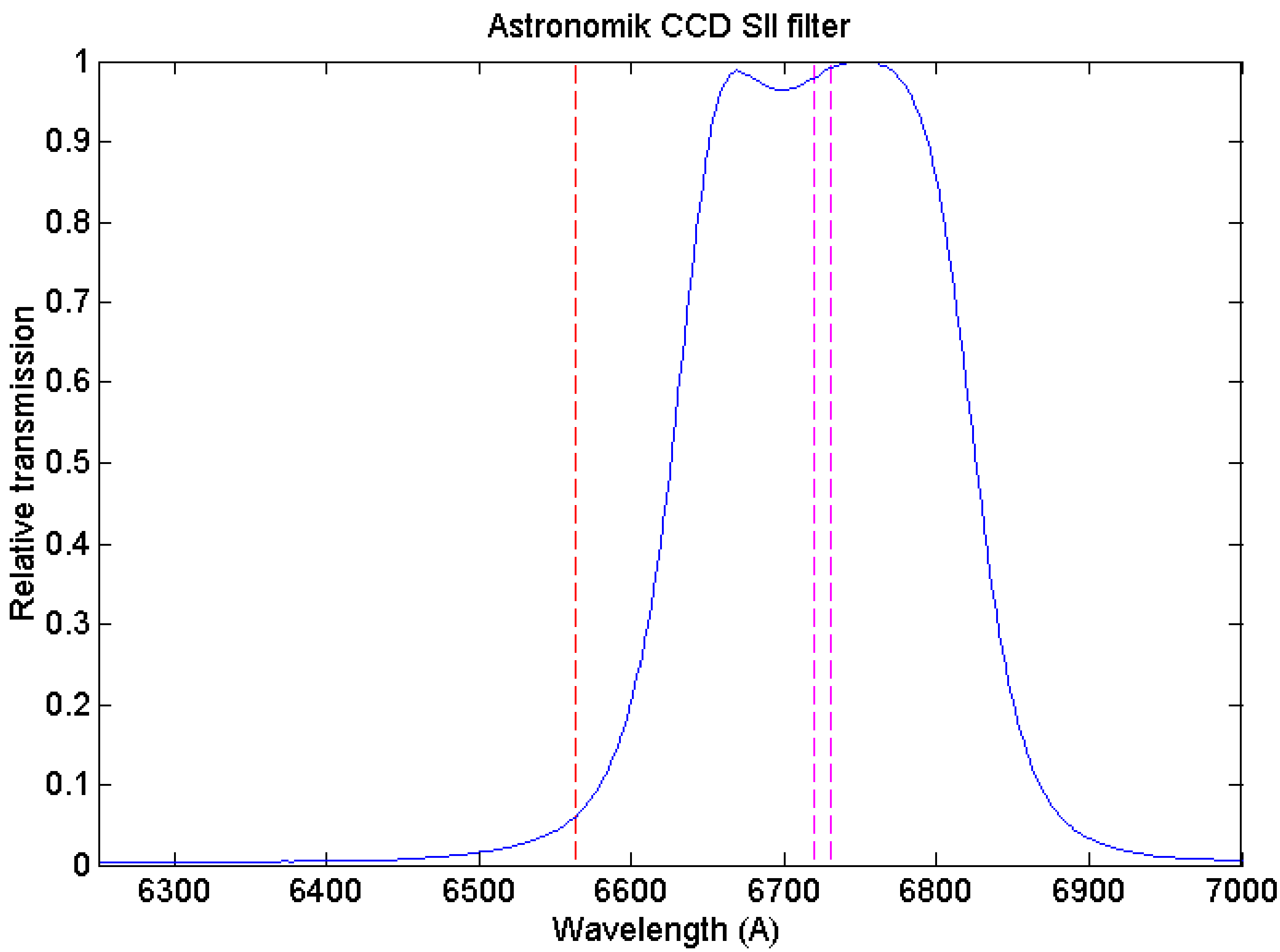




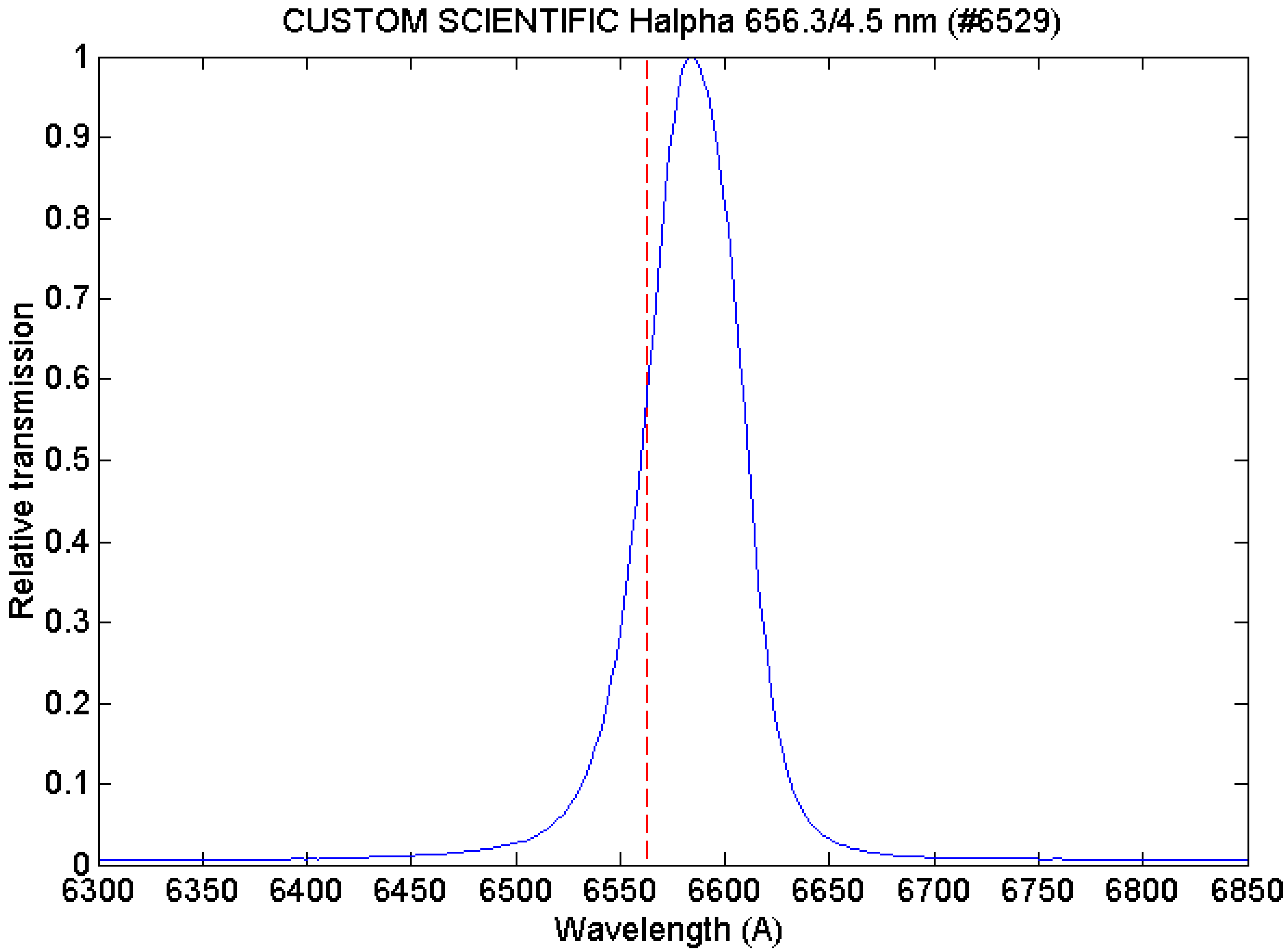
Up image, part of the sun spectrum taken with the LISA spectrograph (intermediate resolution mode - 600 grooves/mm grating). Middle image, same observation condition, only the Astronomik Hα filter #2 is added in the optical beam. The red shift of the transmission curve relative to the Halpha line position is very evident. Down image, an Edmund Optics Halpha is now used (ref. 43-086). The central wavelength position is now correctly adjusted (but in the same time the peak transmission of the Edmund filter is near 50% only, and near 90% for the Astronomik filter).



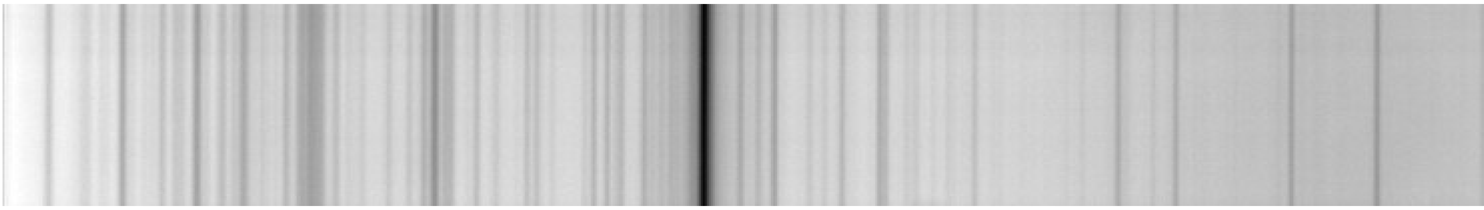
The Astronomik CCD Halpha filter #2 for two incident angles. The curves show progression in pass-band when the angles of incidence of the f/8 beam are varied from 0° to 5° (simulate approximately the marginal rays of a f/5.6 telescope). The dashed line indicate the position of Hα.

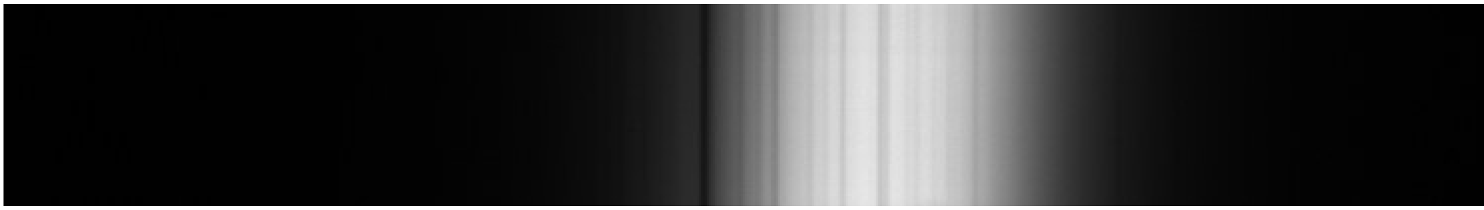


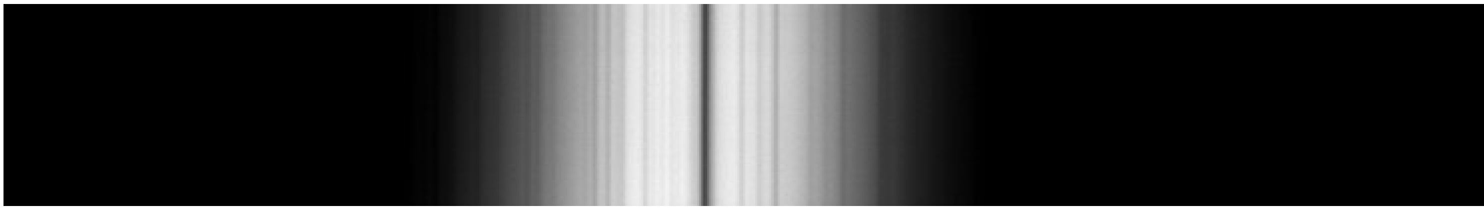
Relative transmission curve of an Astronomik CCD SII filter. The red dashed line indicate the position of Hα line (at 6563 A). The magenta lines indicate the position of [SII] doublet (at 6719 and 6730 A).



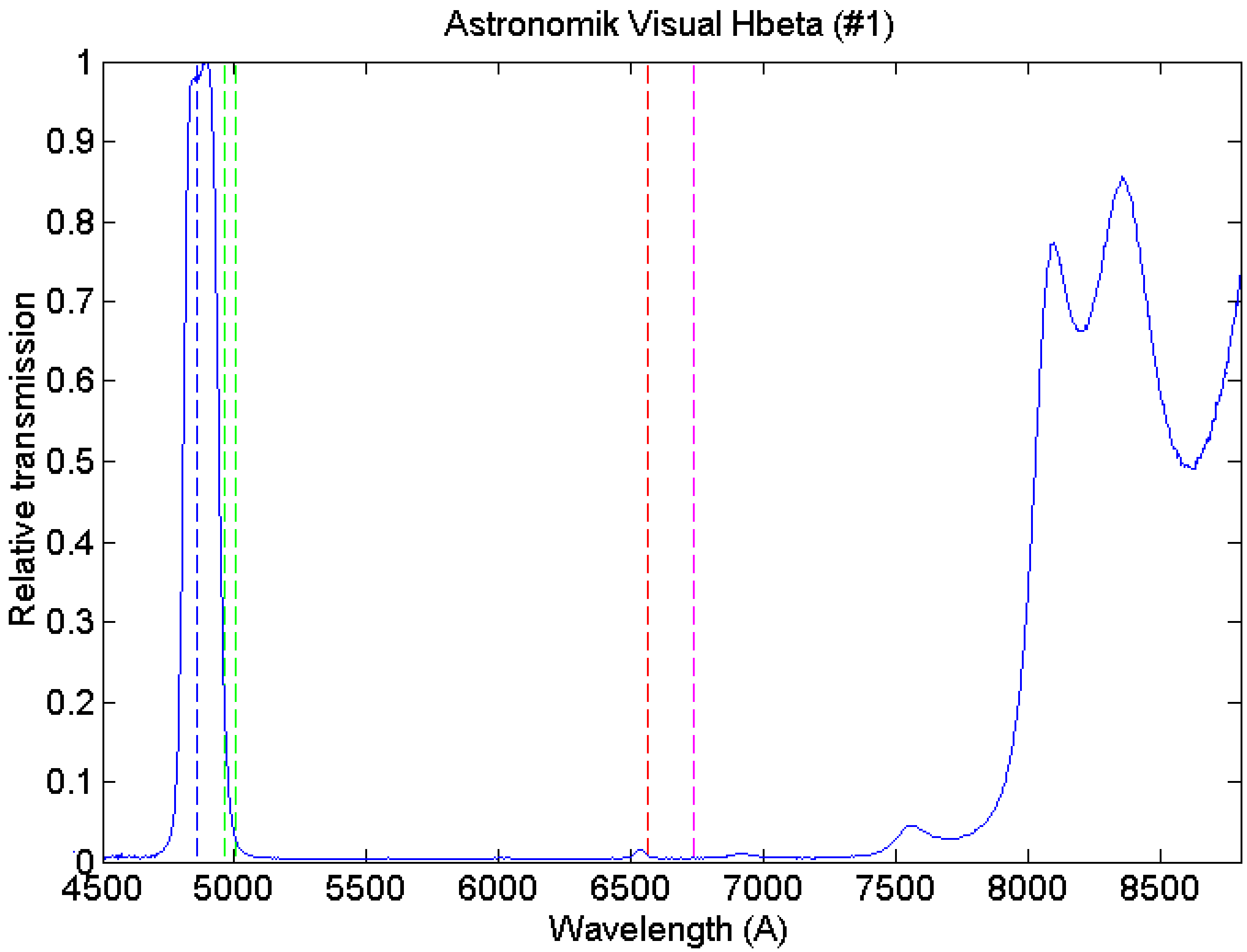
Relative transmission curve of a Custom Scientific Halpha 656.3/4.5nm filter. The peak transmittance of this narrow band filter is significantly shifted toward the red (F/8 aperture optical beam).



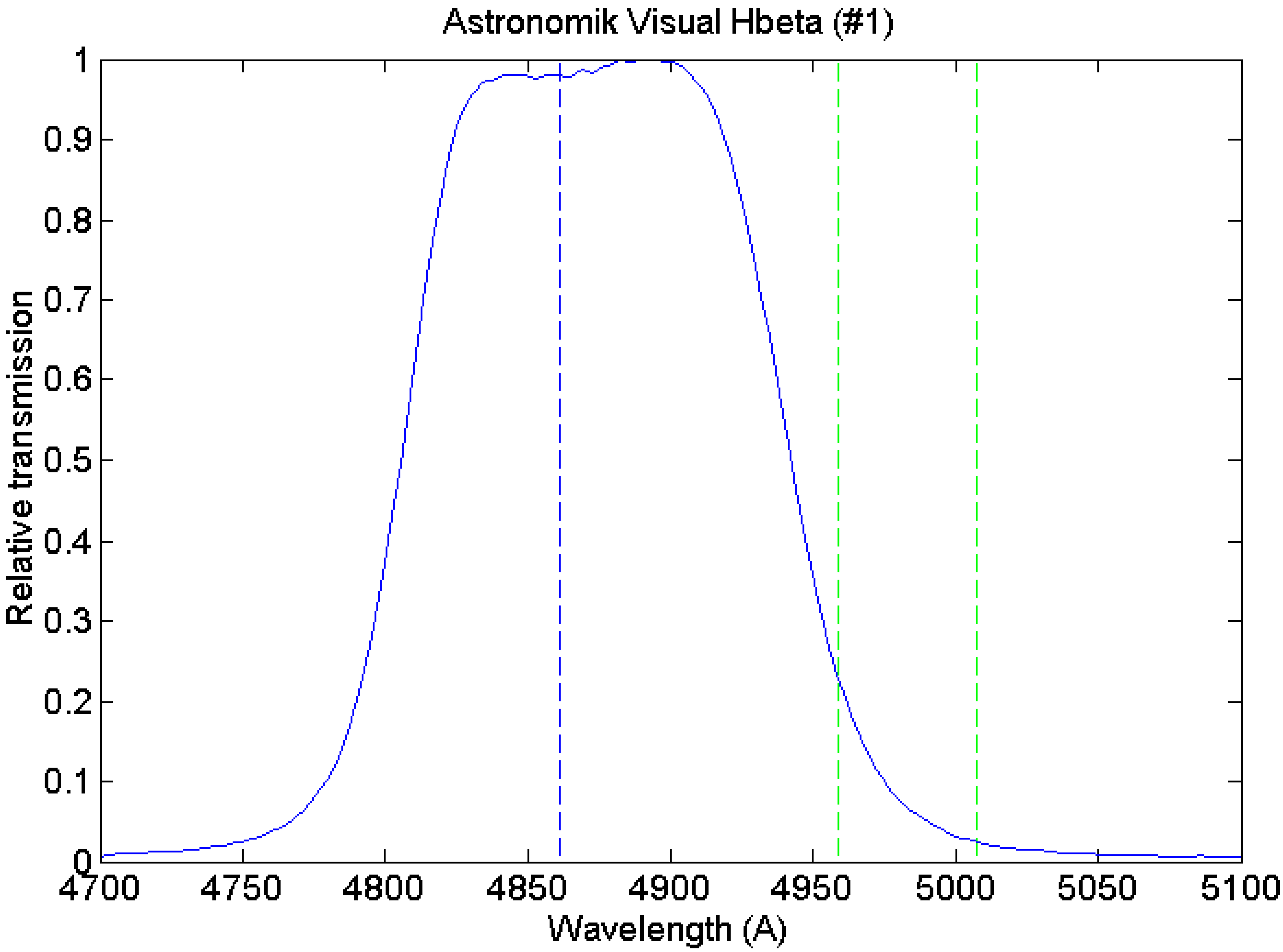




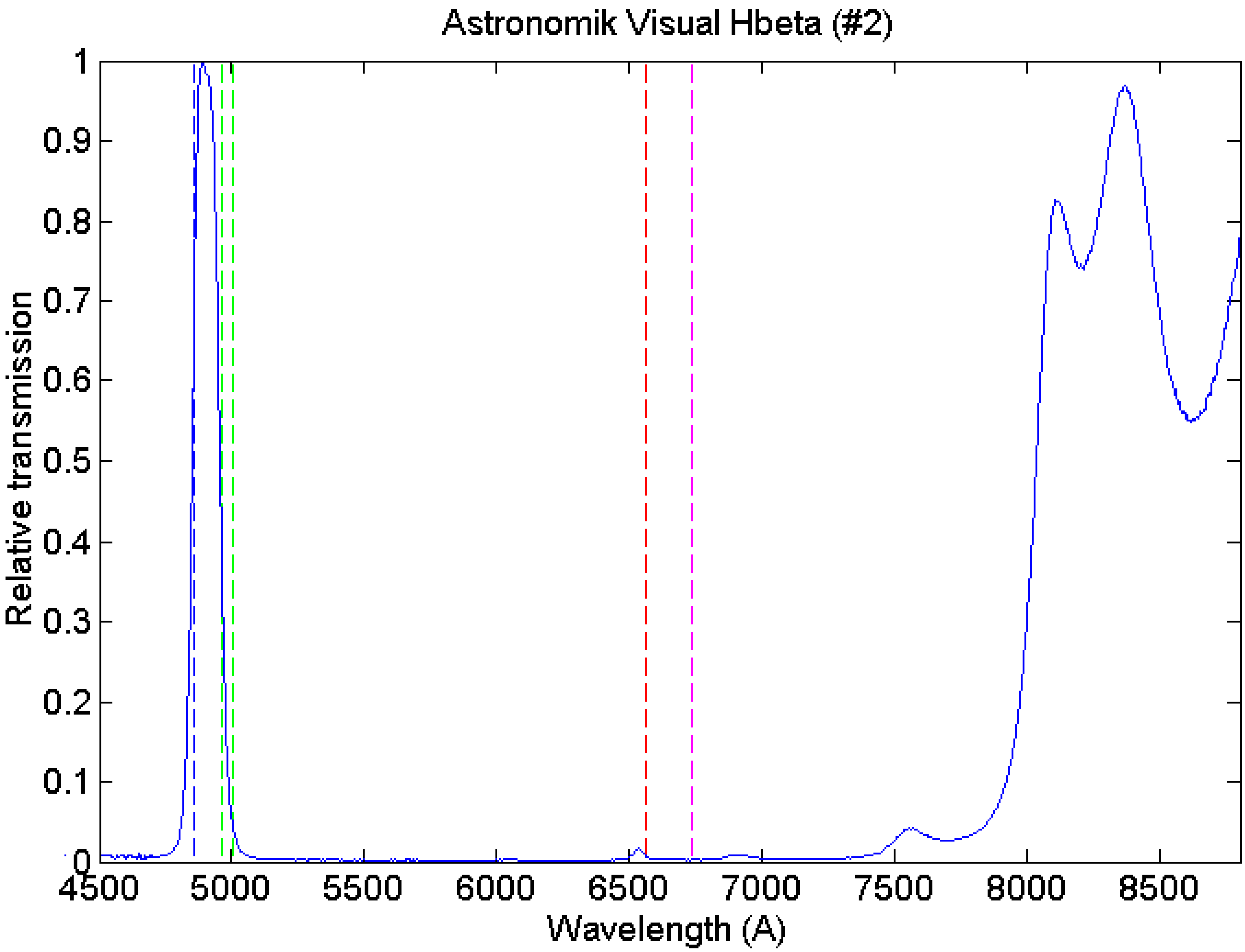
Independent check of the spectral transmission by using the high resolution spectrograph LHIRES3. Up image: standard LHIRES spectrum of the sun - the Halpha line is at the center (sampling of 0.34 A/pixel). Middle image: the Custom Scientific Halpha filter is inserted in the optical beam (just front the entrance slit).The peak transmittance is not superposed to Halpha. Down image: the filter is tilted by a severe angle of 16°. The peak transmittance is now on Halpha line.



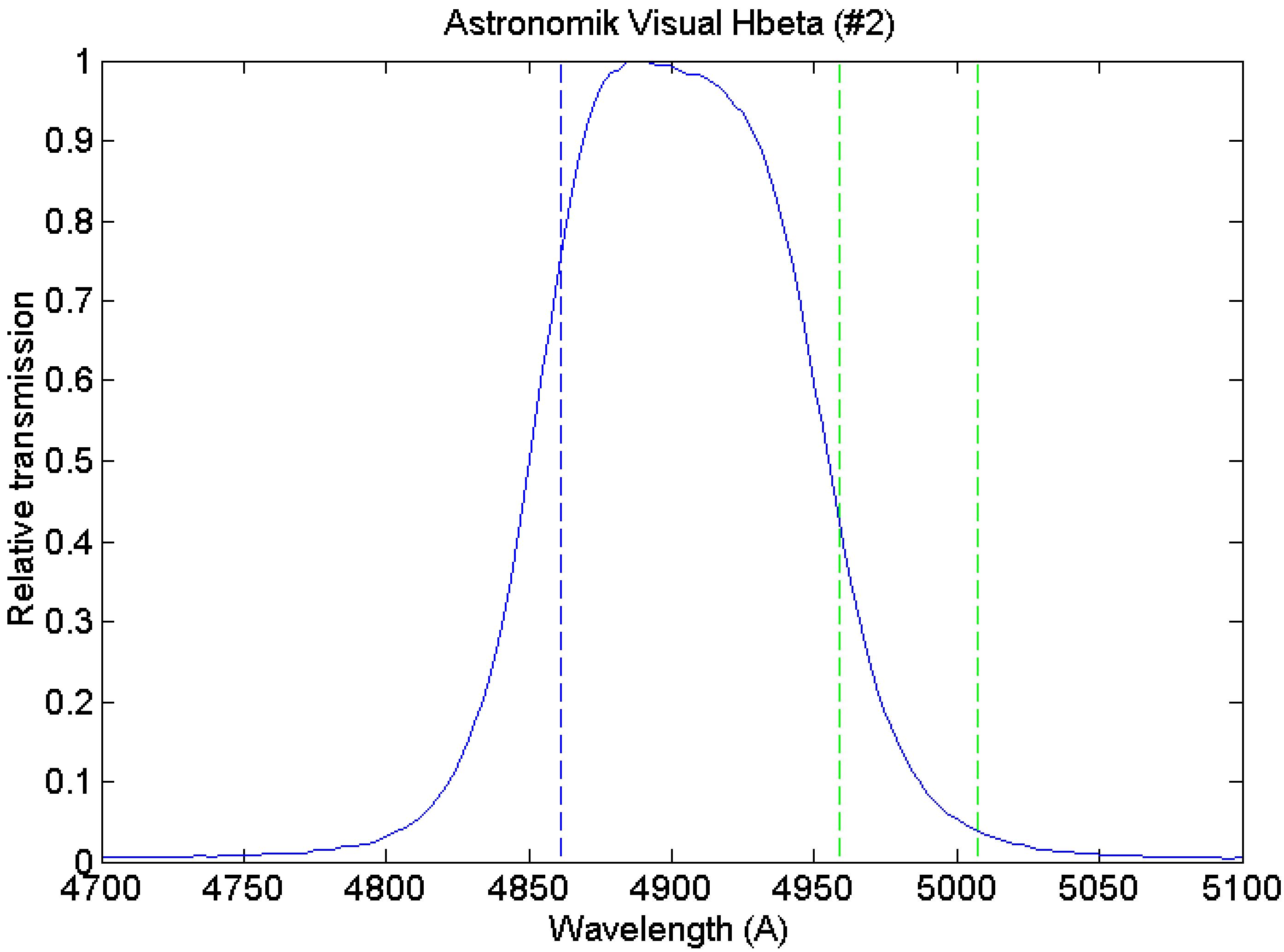
The Astronomik Visual Hbeta filter #1 spectral transmission. Of course, an IR blocking filter is necessary for use this filter in conjunction with an infrared sensitive camera (CCD, moded DSLR, ...).



Detail of the Astronomik Hbeta filter #1 near Hbeta spectral line. The bleue dashed line indicate the position of Hβ line (at 4861 A). The Cyan dashed lines indicate the position of the [OIII] doublet at 5007 A (the most intense component) and 4959 A.

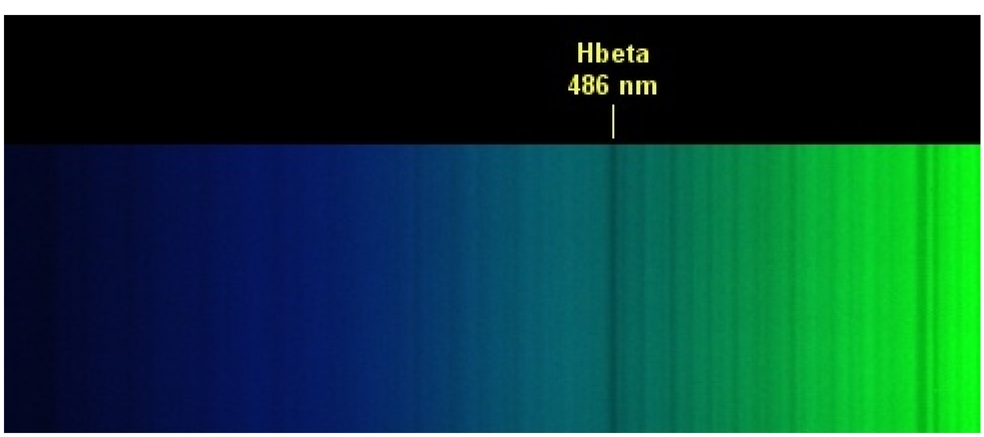


The Astronomik Visual Hbeta filter #2 spectral transmission. From left to right the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα at 6563 A (red) and [SII] line at 6730 A (cyan).

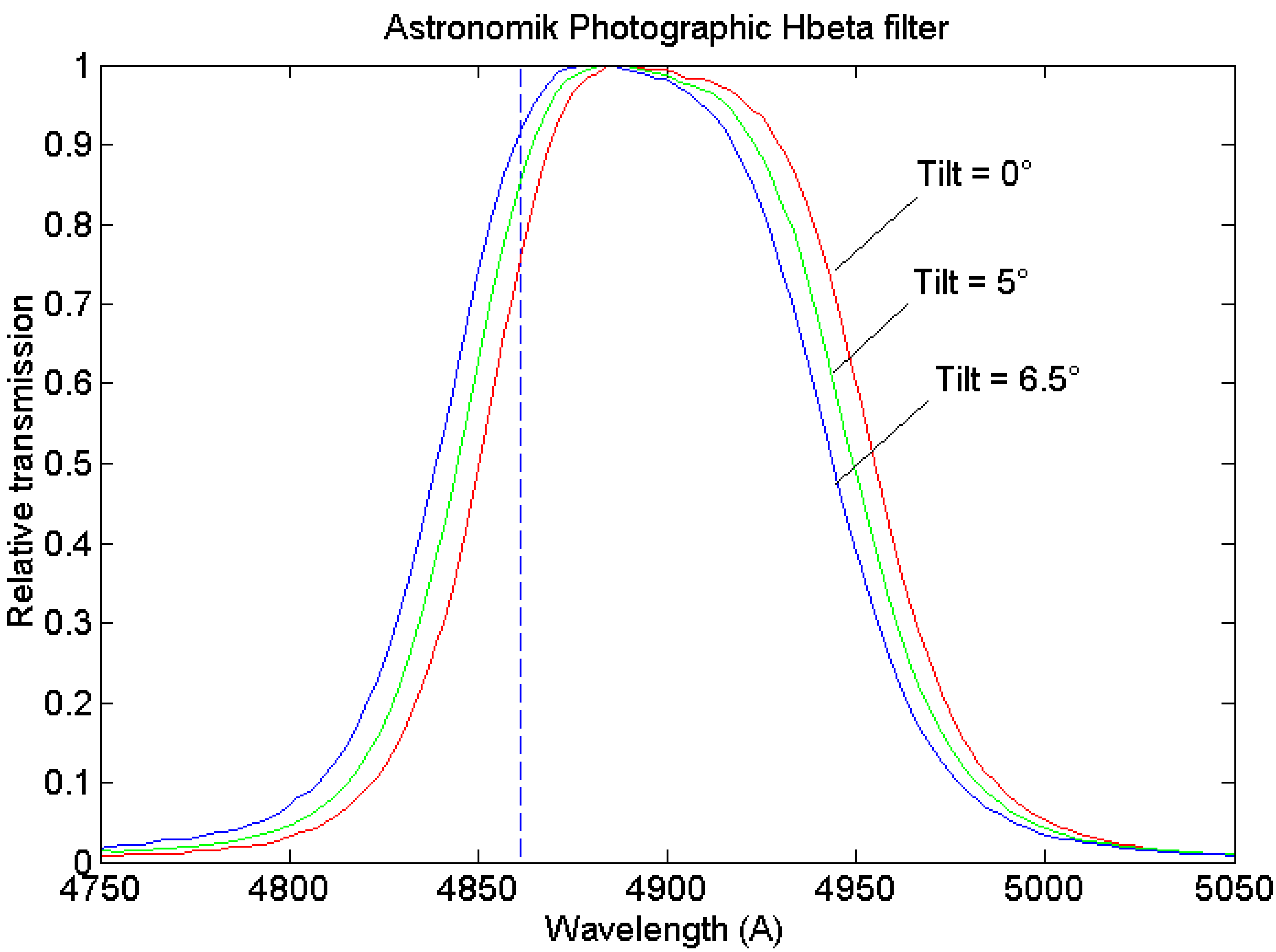


Detail of the Astronomik Photographic (or Visual) Hbeta filter transmission curve. The bleue dashed line indicate the position of Hb line (at 4861 A). The Cyan dashed lines indicate the position of the [OIII] doublet at 5007 A (the most intense) and 4959 A.

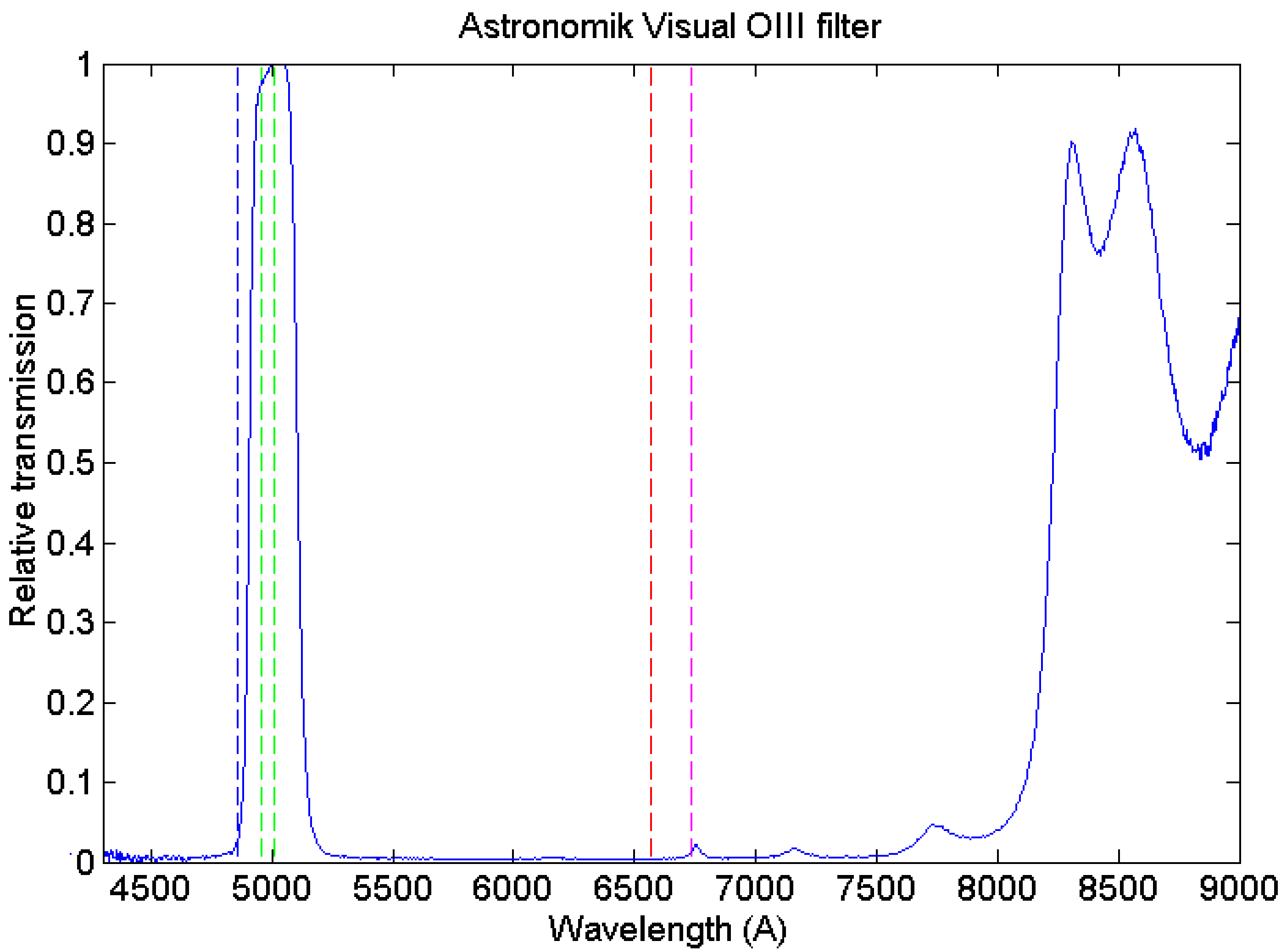
The same problem is encounter about the peak transmission of the bandwidth as the Astronomik Hα filter #2. The shift is more severe here ! Another proof...



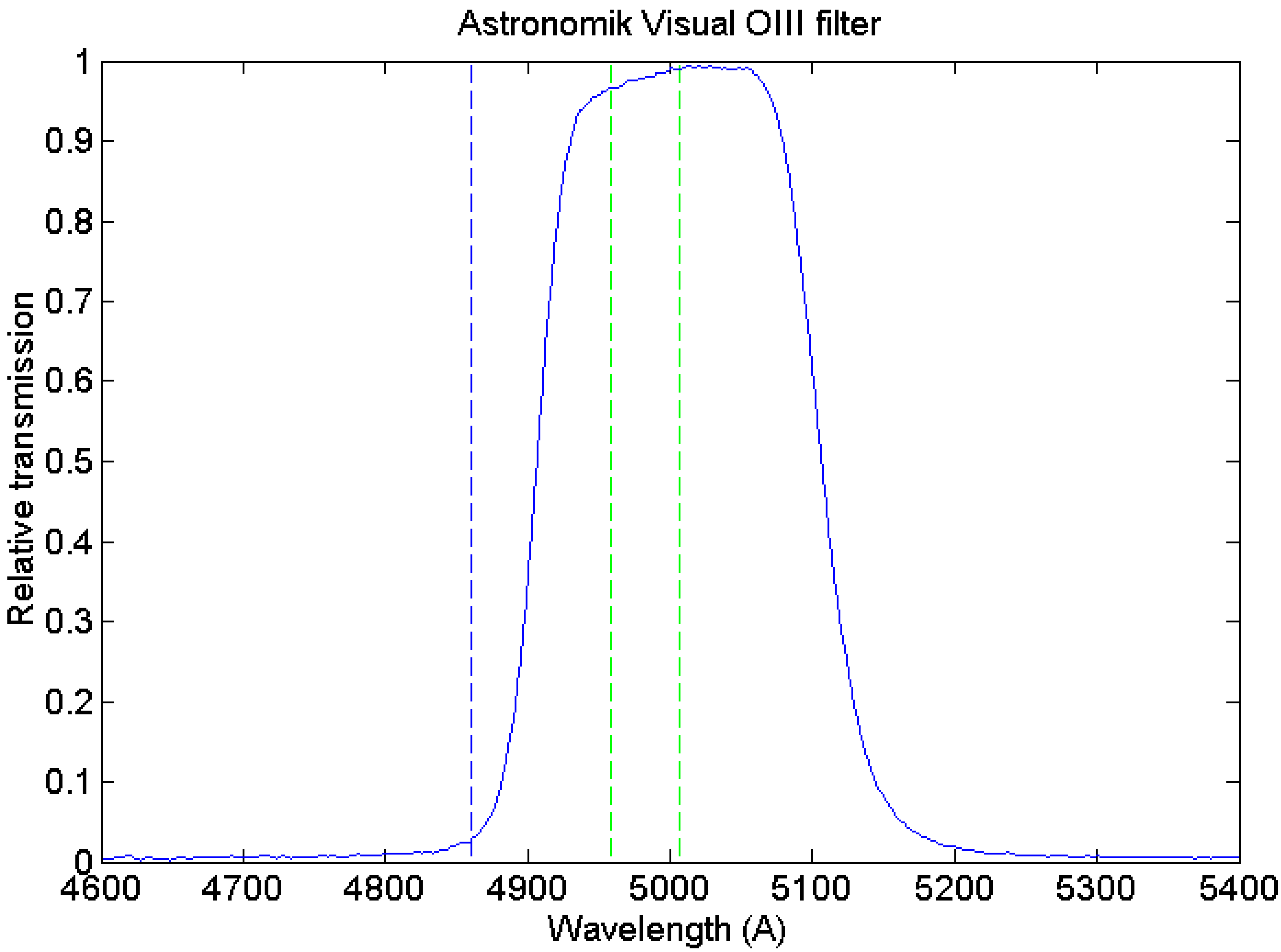
Up image, part of the sun spectrum taken with the LISA spectrograph. Down image, same observation condition, only the Astronomik Hβ filter #2 is added in the optical beam. The Hβ line is nearly out of band of the filter.



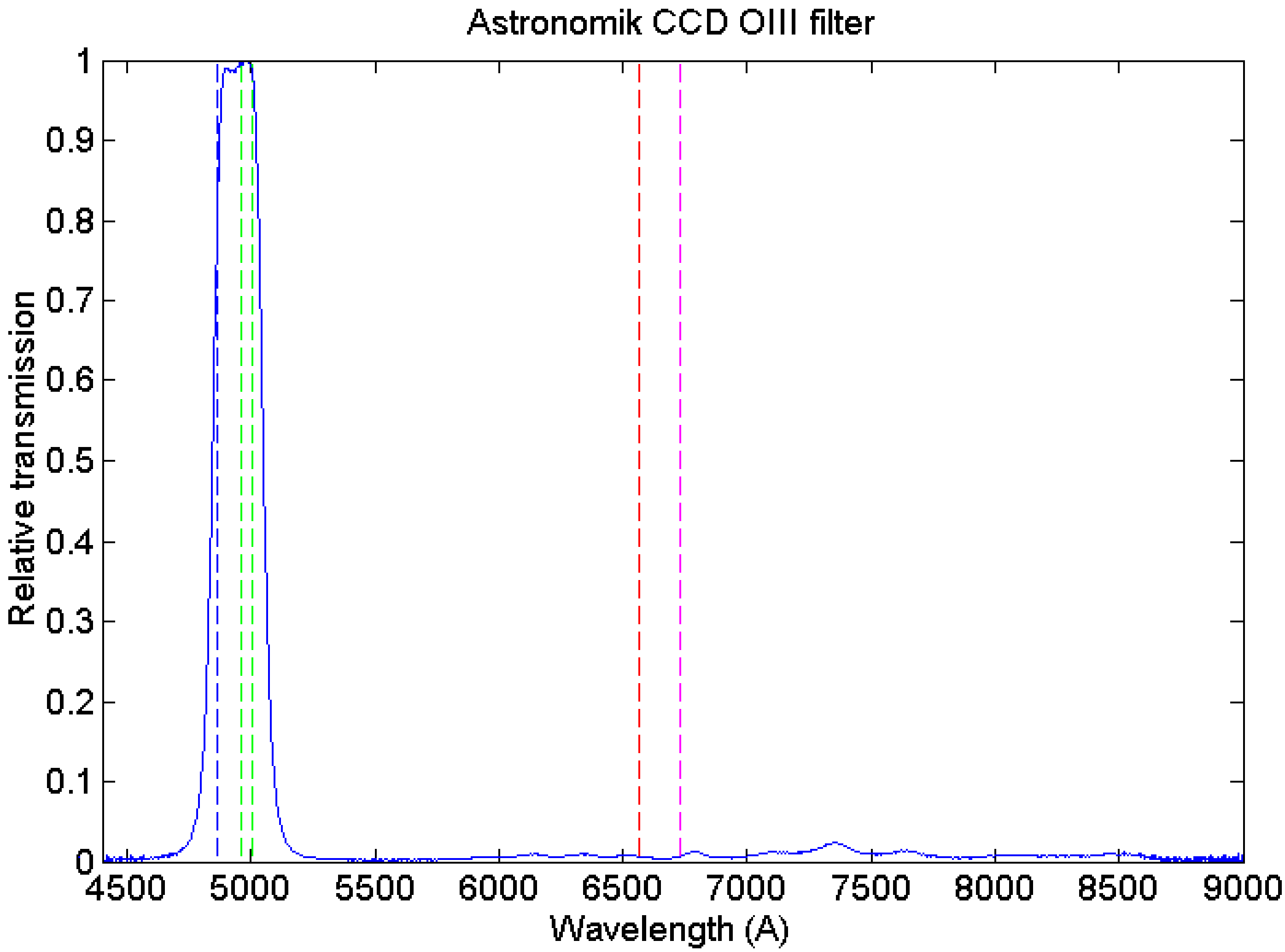
The Astronomik Photographic (or visual) Hbeta filter #2 transmission for three incident angles. 0° tilt curve, the f/8 input beam is normal to the filter surfaces. 5° tilt curve, the filter is tilted by a angle of 5° relative to the f/8 input beam (simulate approximately the marginal rays of a f/5.6 telescope). 6.5° tilt curve, the filter is tilted by a angle of 6.5° relative to the f/8 input beam (simulate approximately the marginal rays of a f/4.3 telescope). The dashed line indicate the position of Hβ.



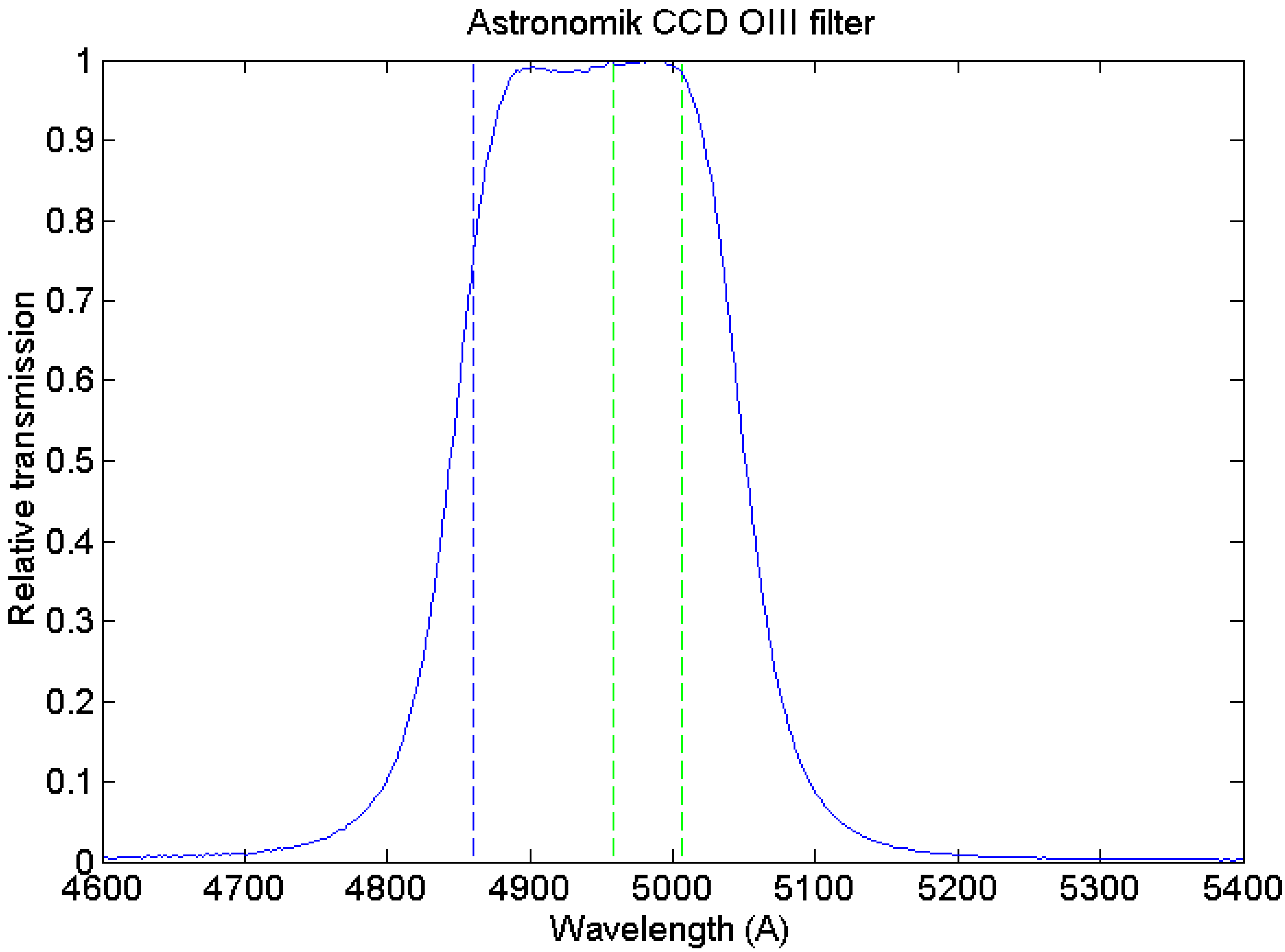
Transmission curve of an Astronomik Visual OIII filter. From left to right the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα at 6563 A (red) and [SII] line at 6730 A (cyan).



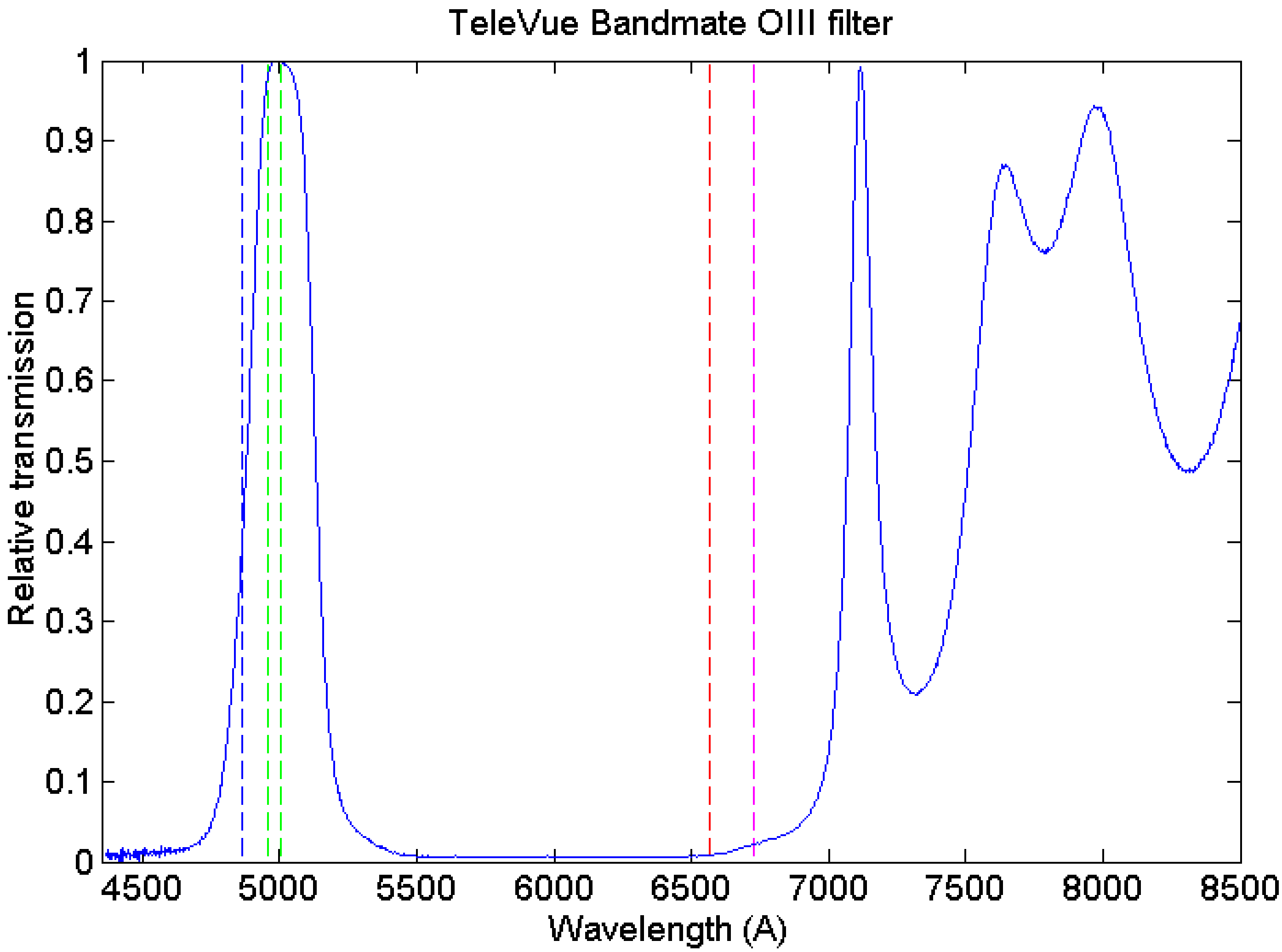
Detail of the Astronomik Visual [OIII] filter transmission curve.



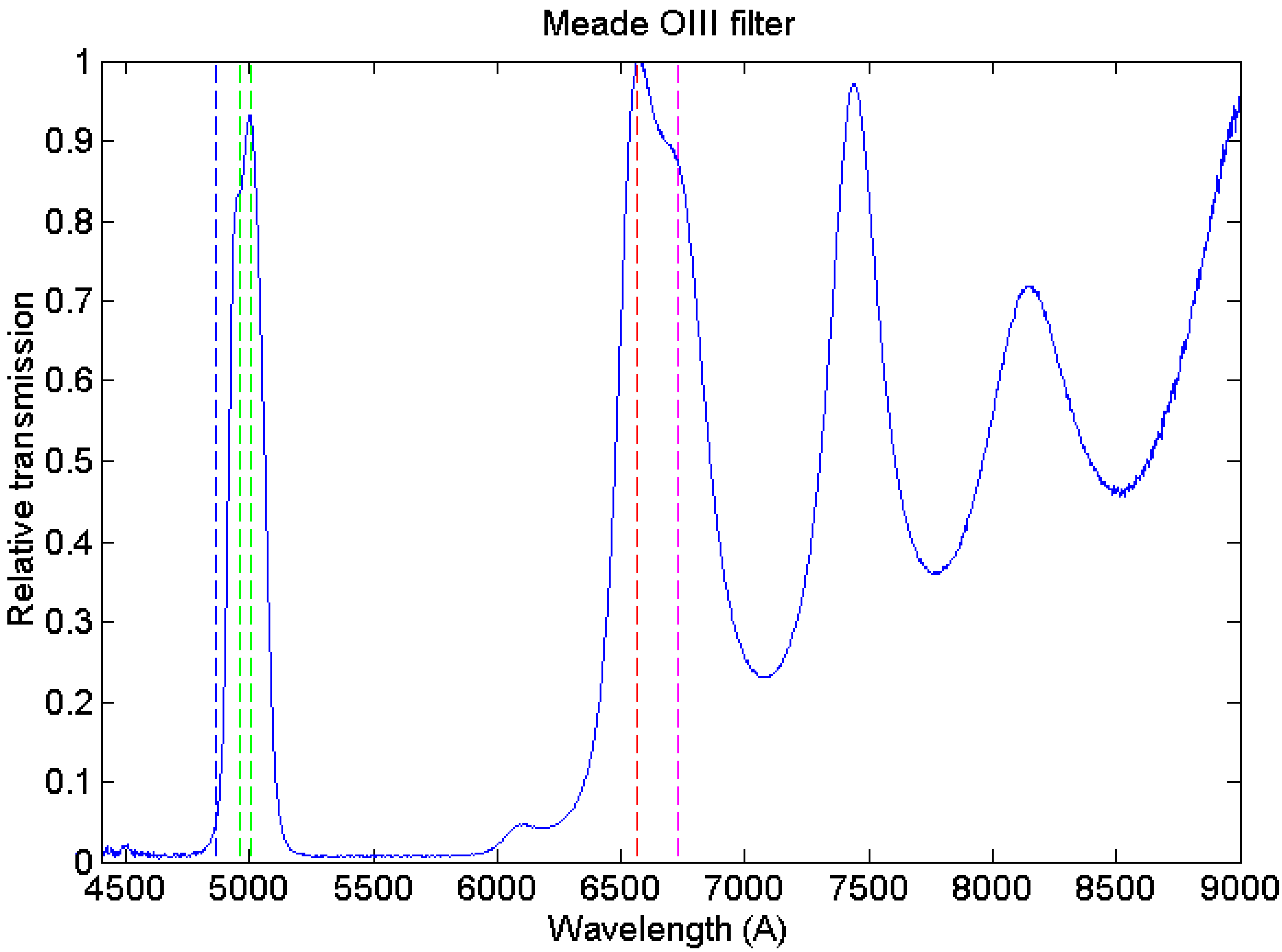
Transmission curve of an Astronomik CCD [OIII] filter.



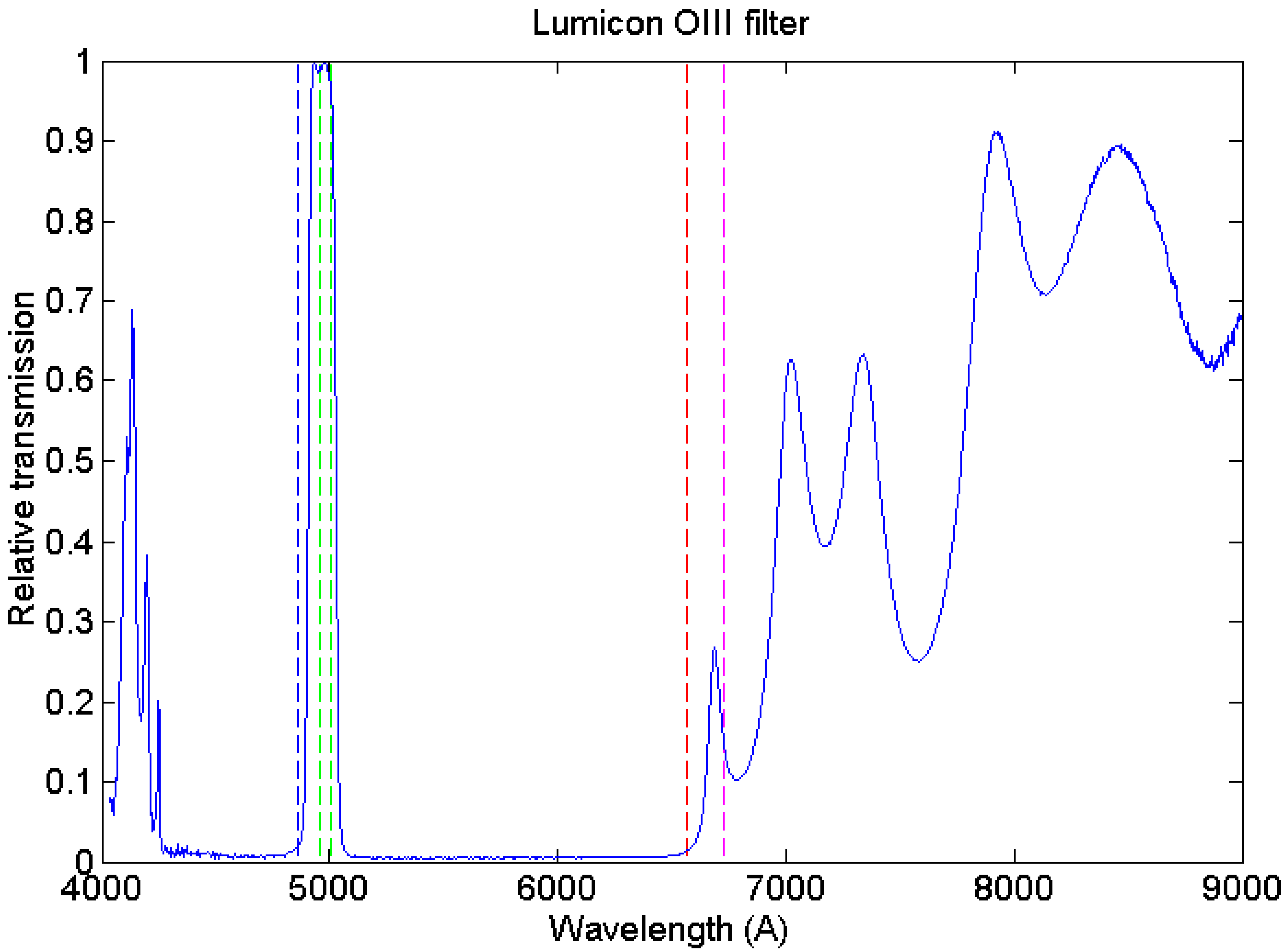
Detail of the Astronomik CCD [OIII] filter transmission. The bleue dashed line indicate the position of Hβ line (at 4861 A). The Cyan dashed lines indicate the position of the [OIII] doublet at 5007 A (the most intense) and 4959 A. This filter is not a pure oxygen filter, some light of neutral hydrogen is also transmitted.



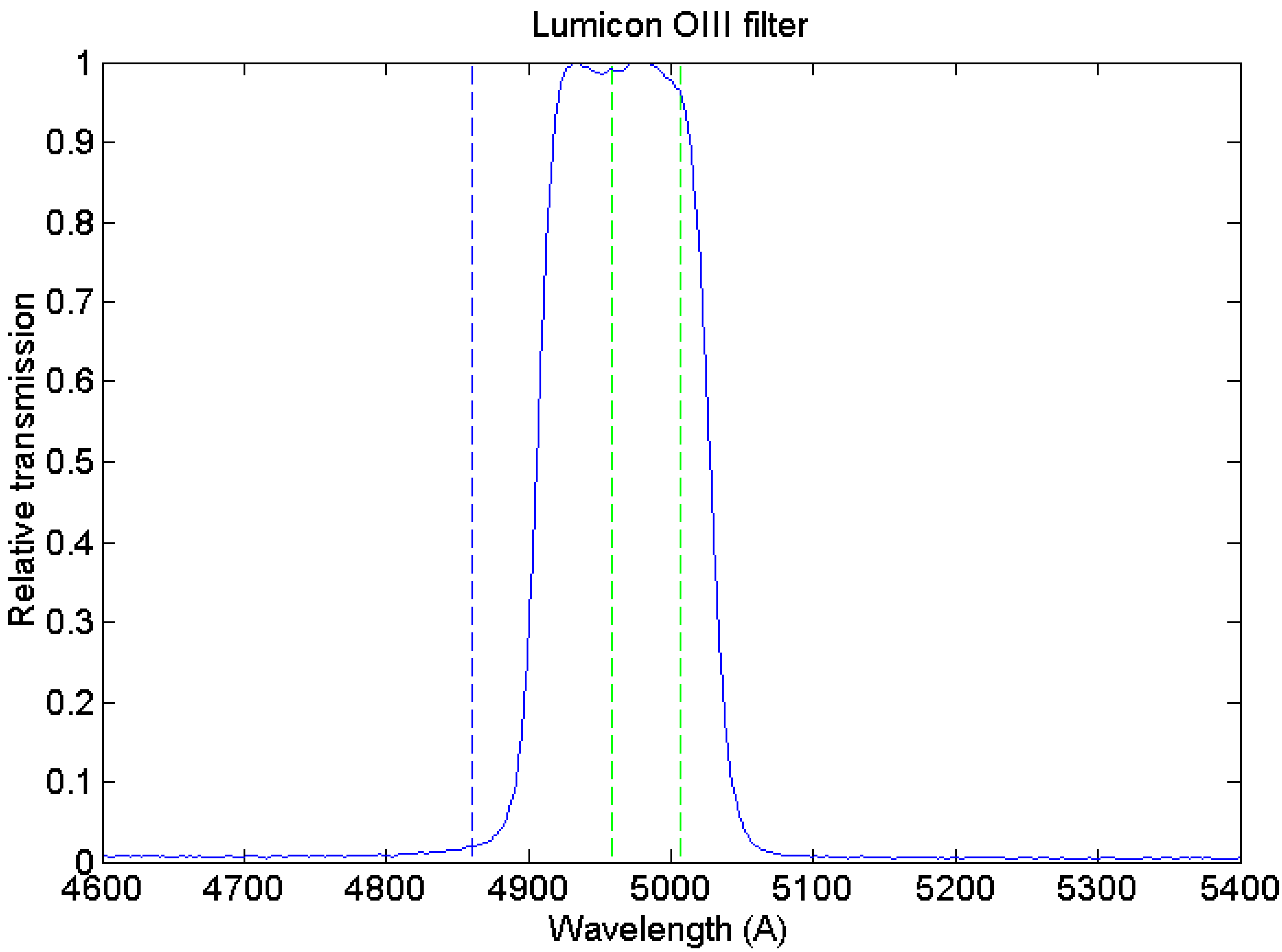
Spectral transmission of the TeleVue Bandmate [OIII] filter.



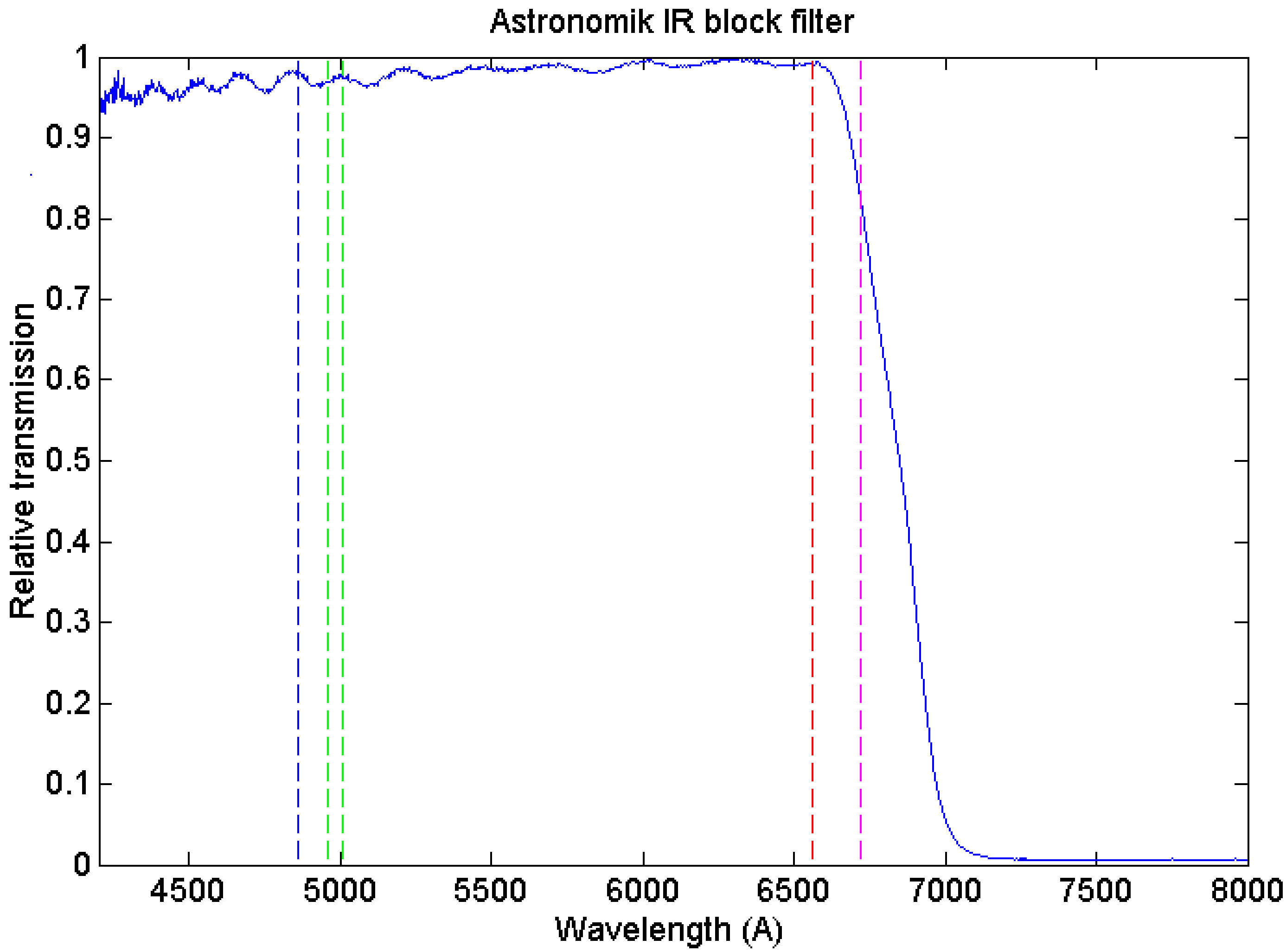
Spectral transmission of the Meade [OIII] filter.



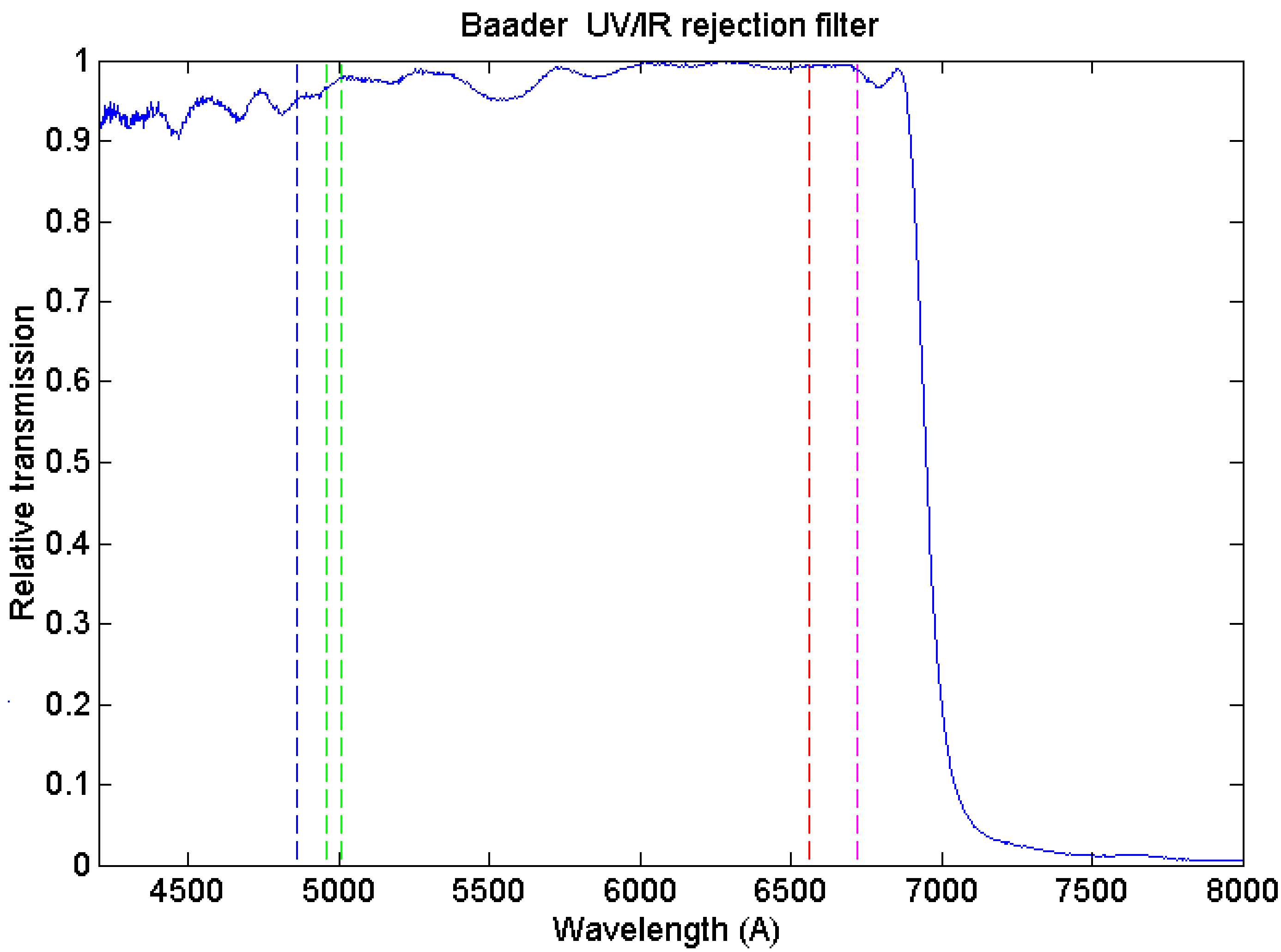
Spectral transmission of the Lumicon [OIII] filter.



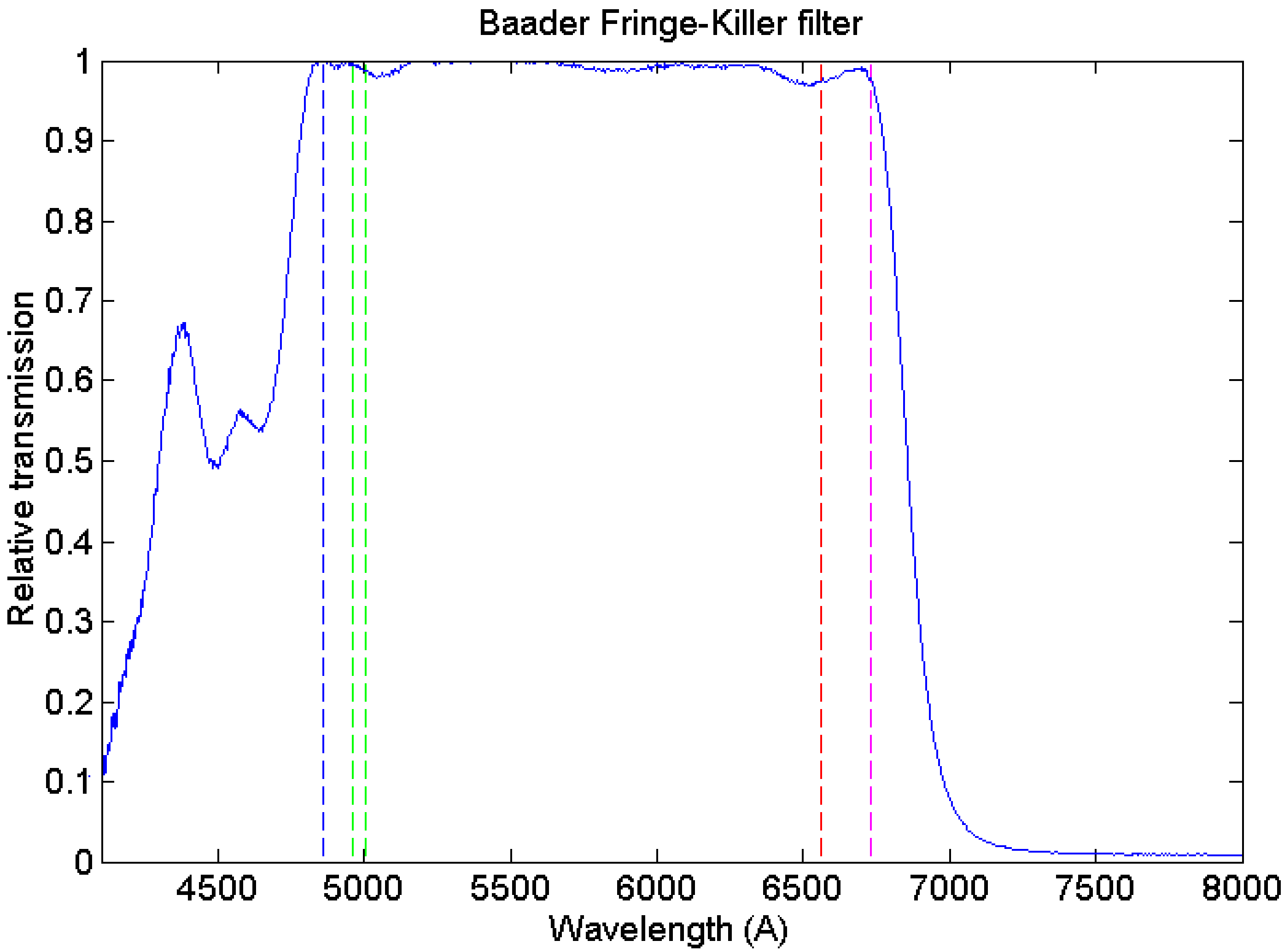
Detail of the Lumicon [OIII] filter.



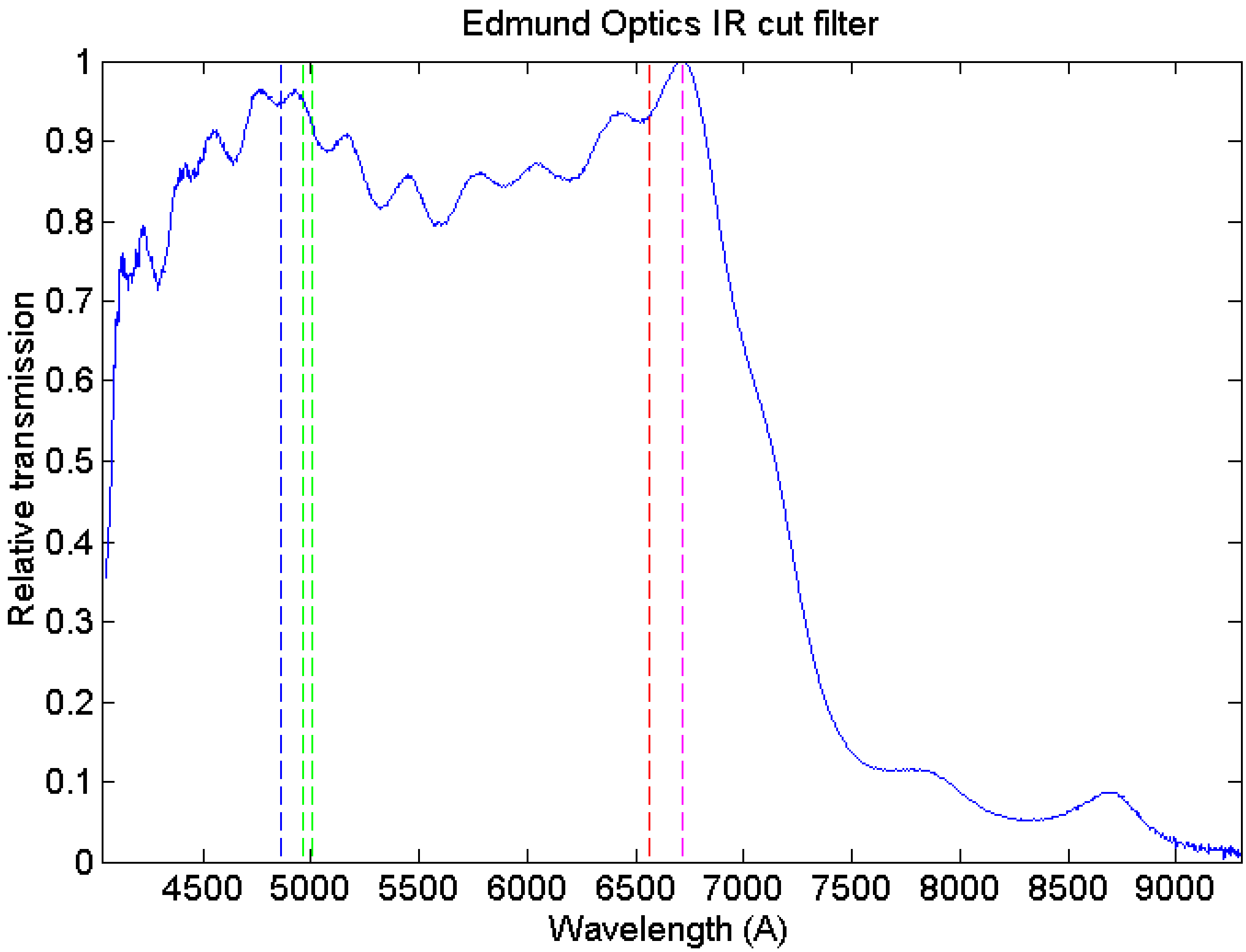
The Astronomik IR block filter spectral transmission. From left to right the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα (red) and [SII] doublet (cyan).



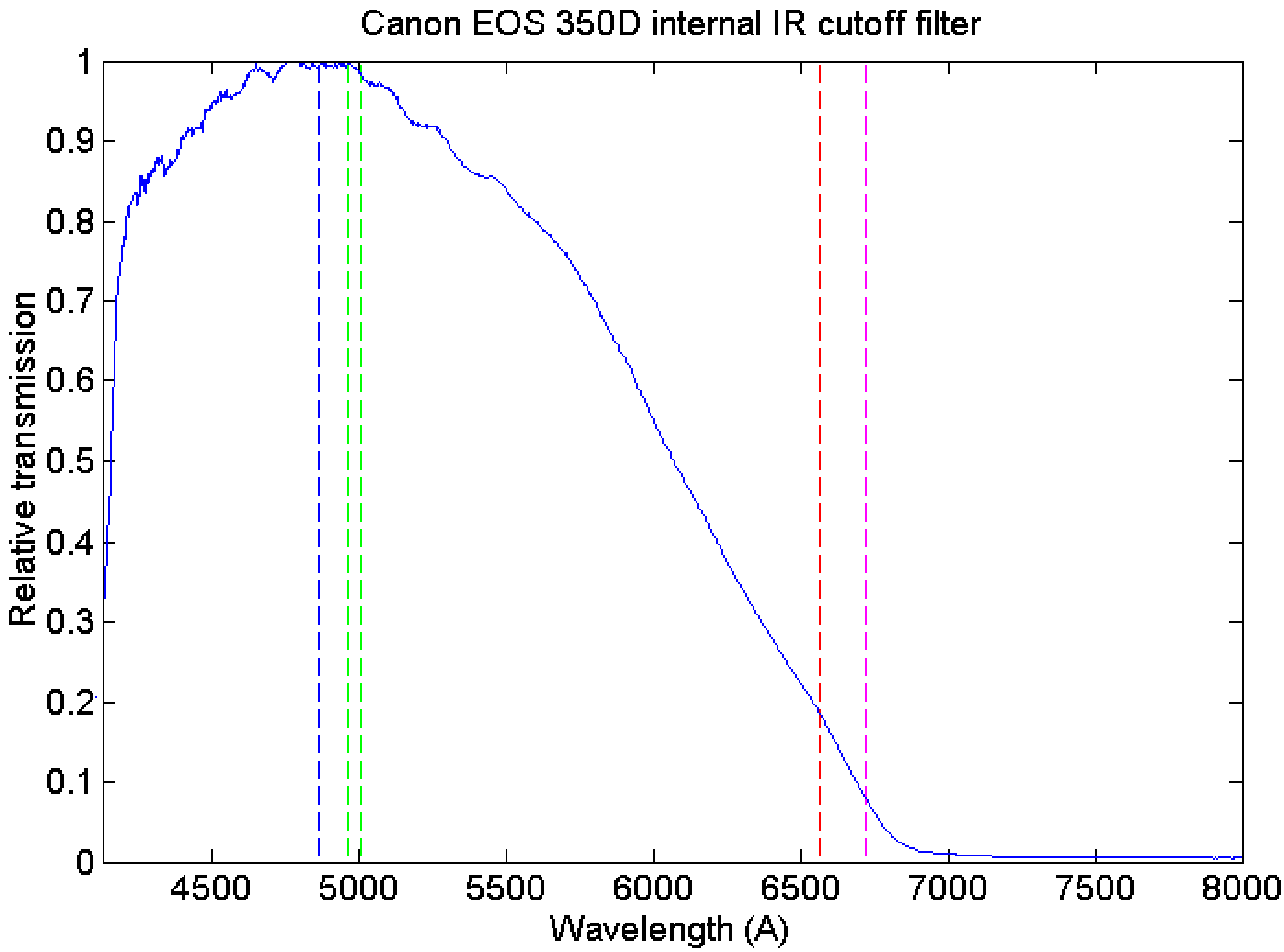
The Badder UV/IR rejection filter spectral transmission. From left to right, the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα (red) and [SII] doublet (cyan).



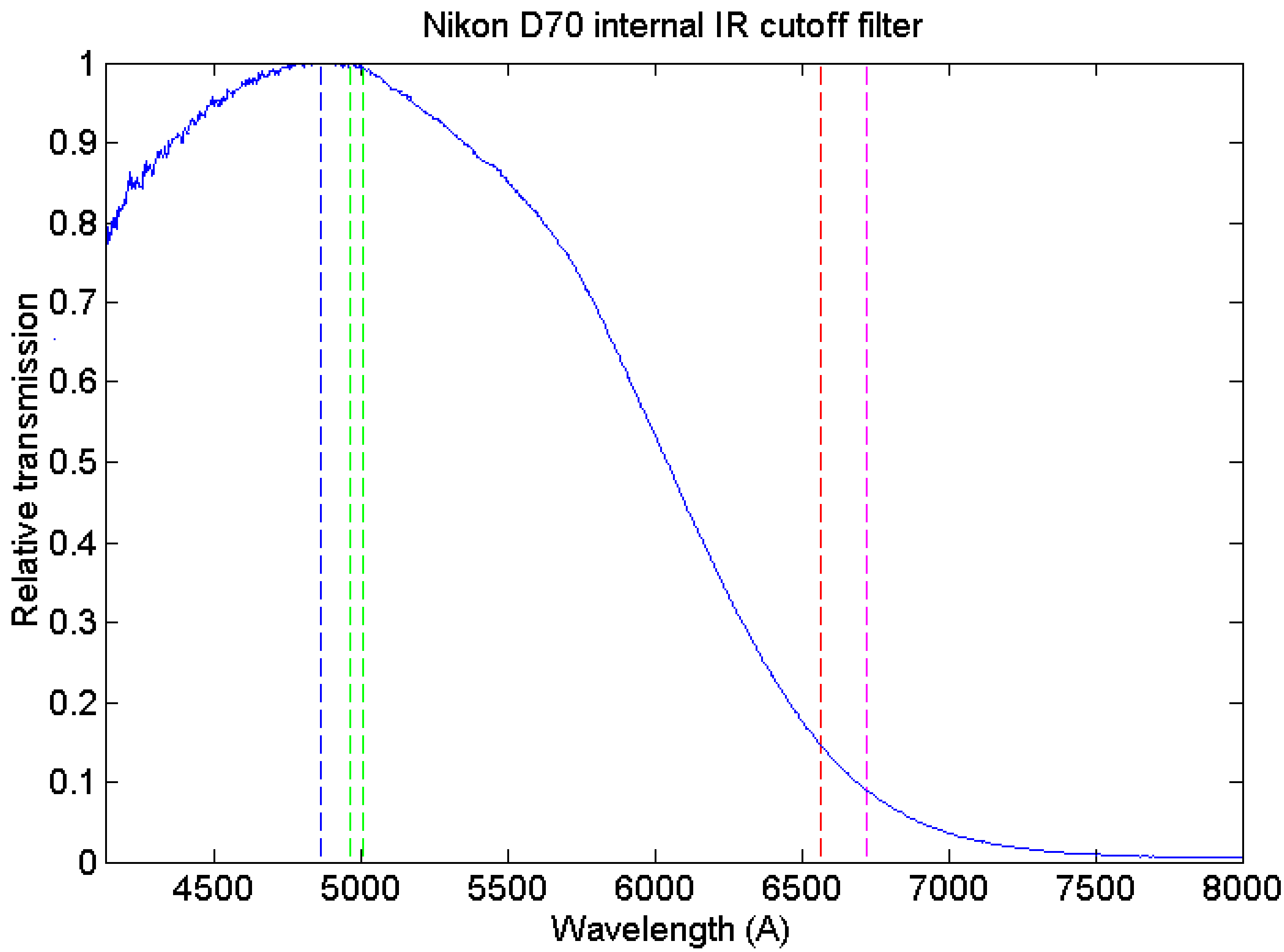
The spectral transmission of a Baader Fringe-Killer filter.



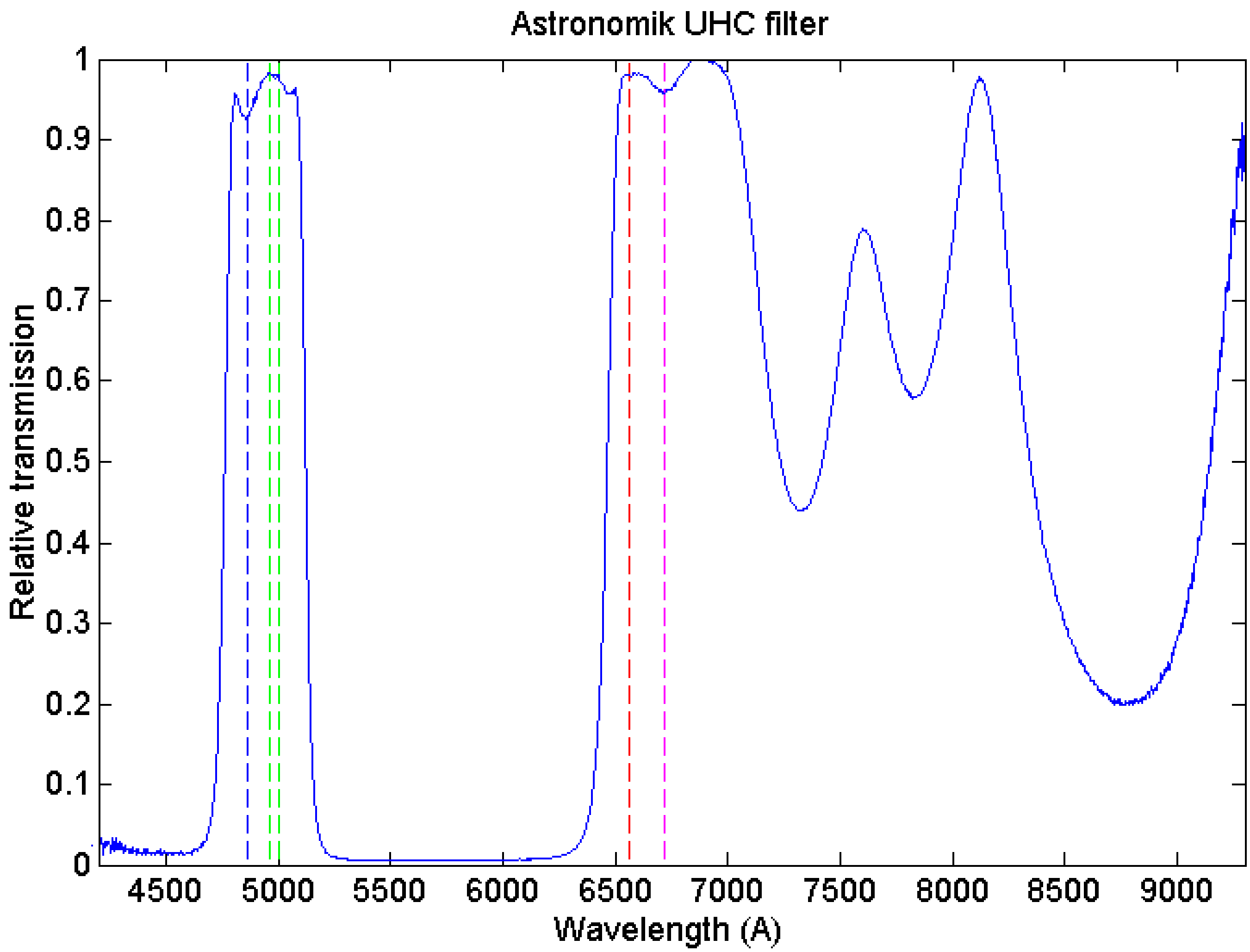
The Edmund Optics IR rejection filter spectral transmission.



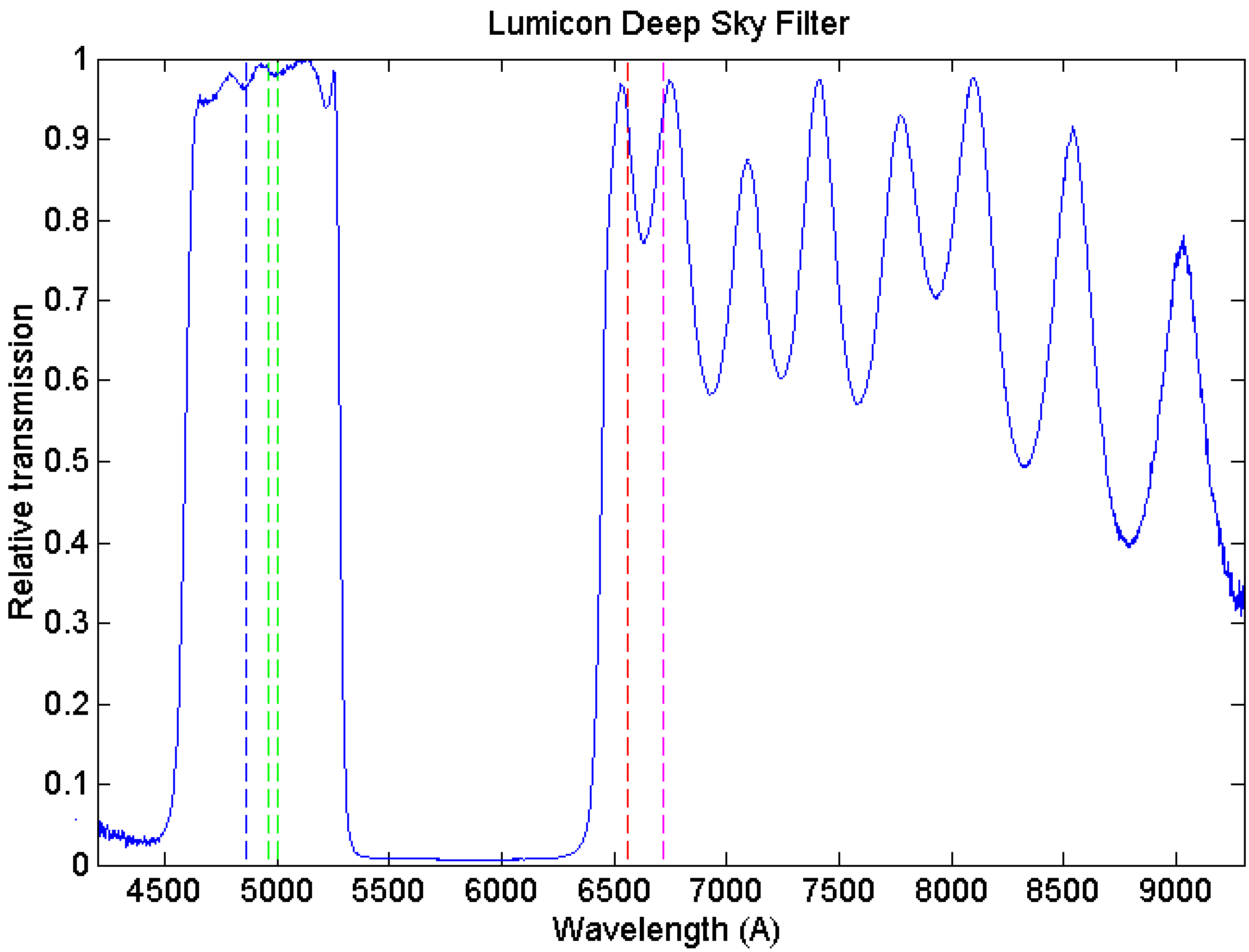
The Canon EOS 350D internal IR cut filter. From left to right, the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα (red) and [SII] doublet (cyan).



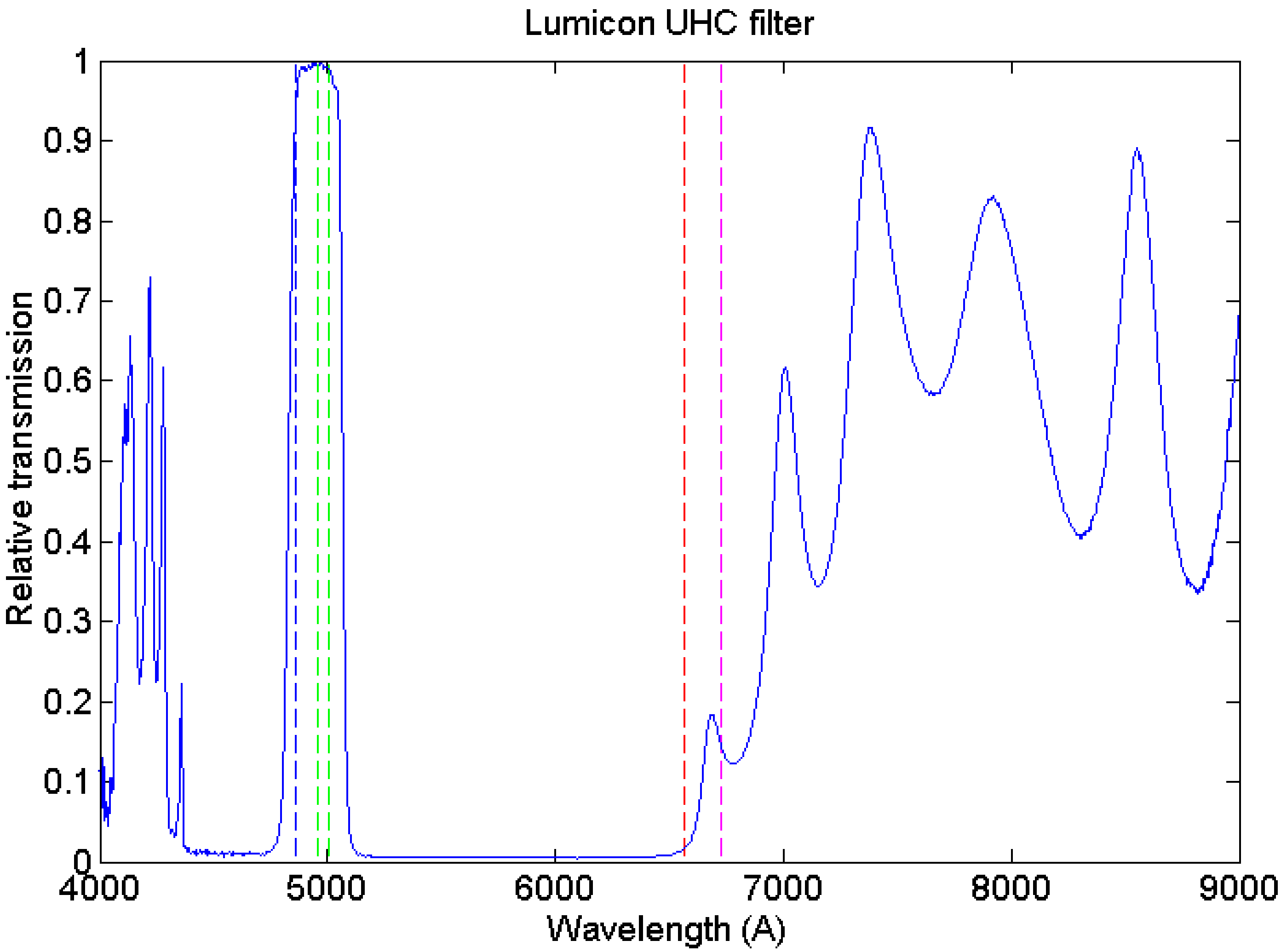
The Nikon D70 internal IR cut filter. From left to right, the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα (red) and [SII] doublet (cyan).



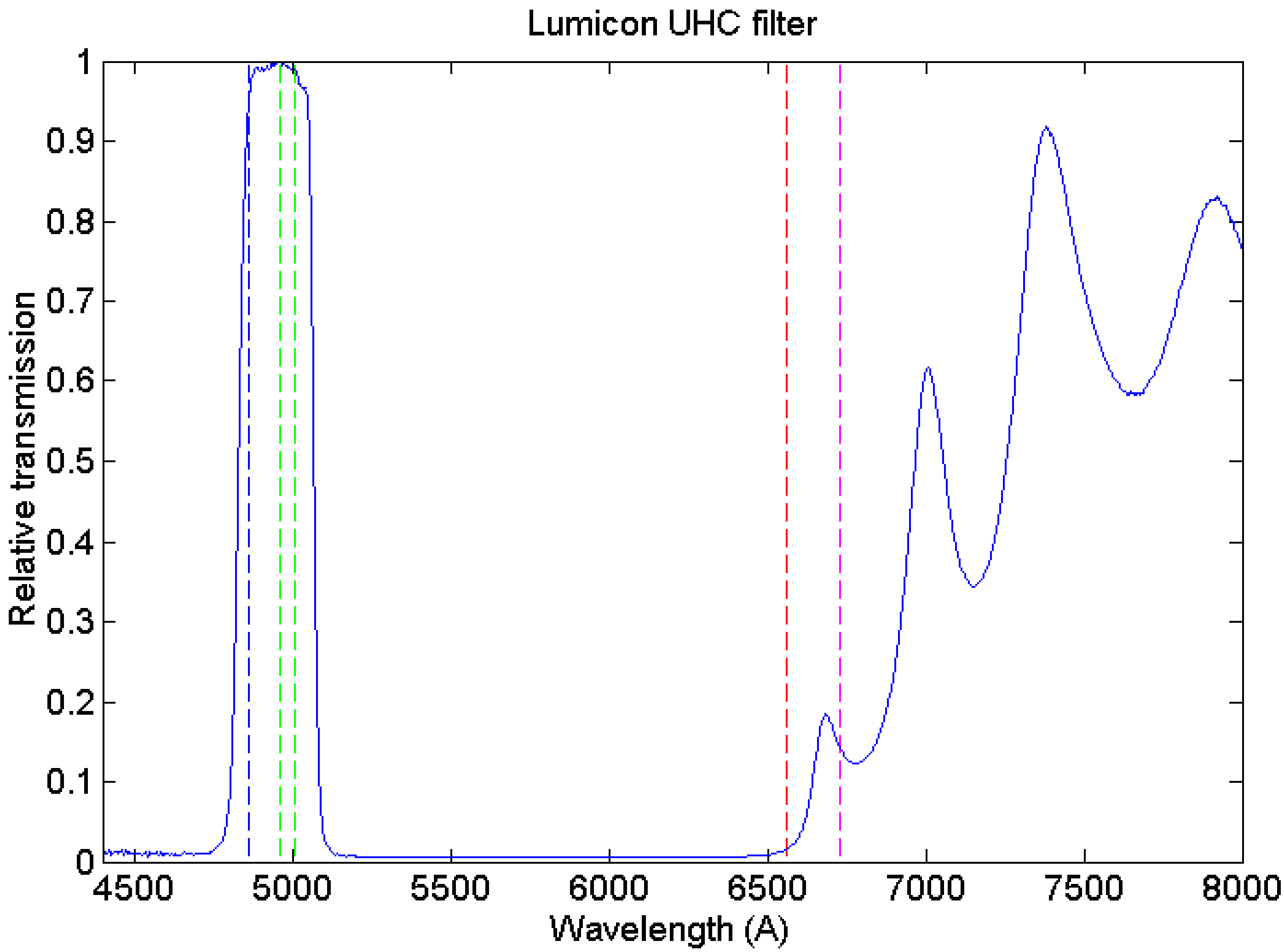
The Astronomik UHC filter spectral transmission. From left to right, the dashed lines indicates the position of Hβ (bleue), [OIII] doublet (green), Hα (red) and [SII] doublet (cyan). Click here for an example of use.



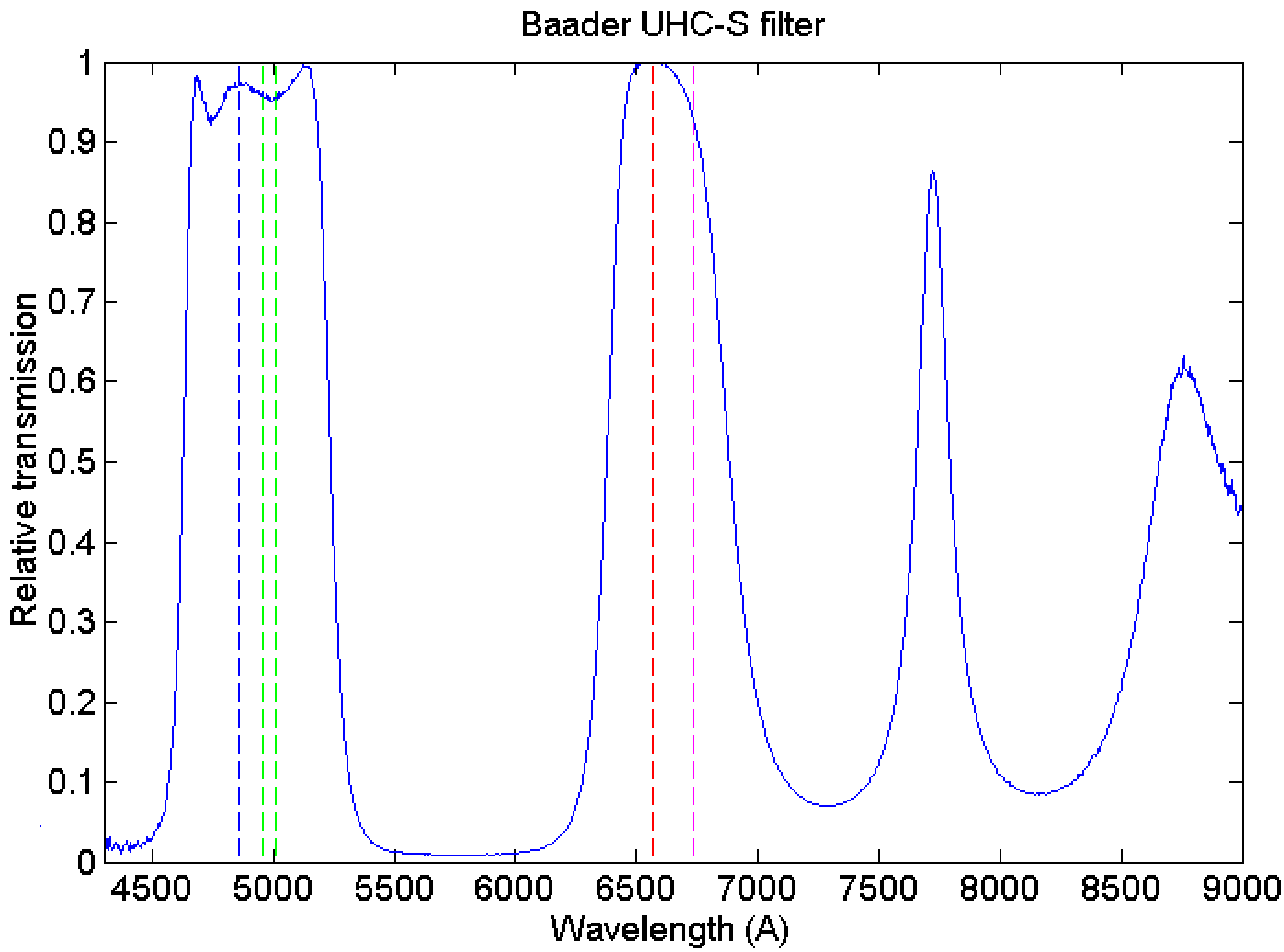
The Lumicon Deep Sky filter spectral transmission.



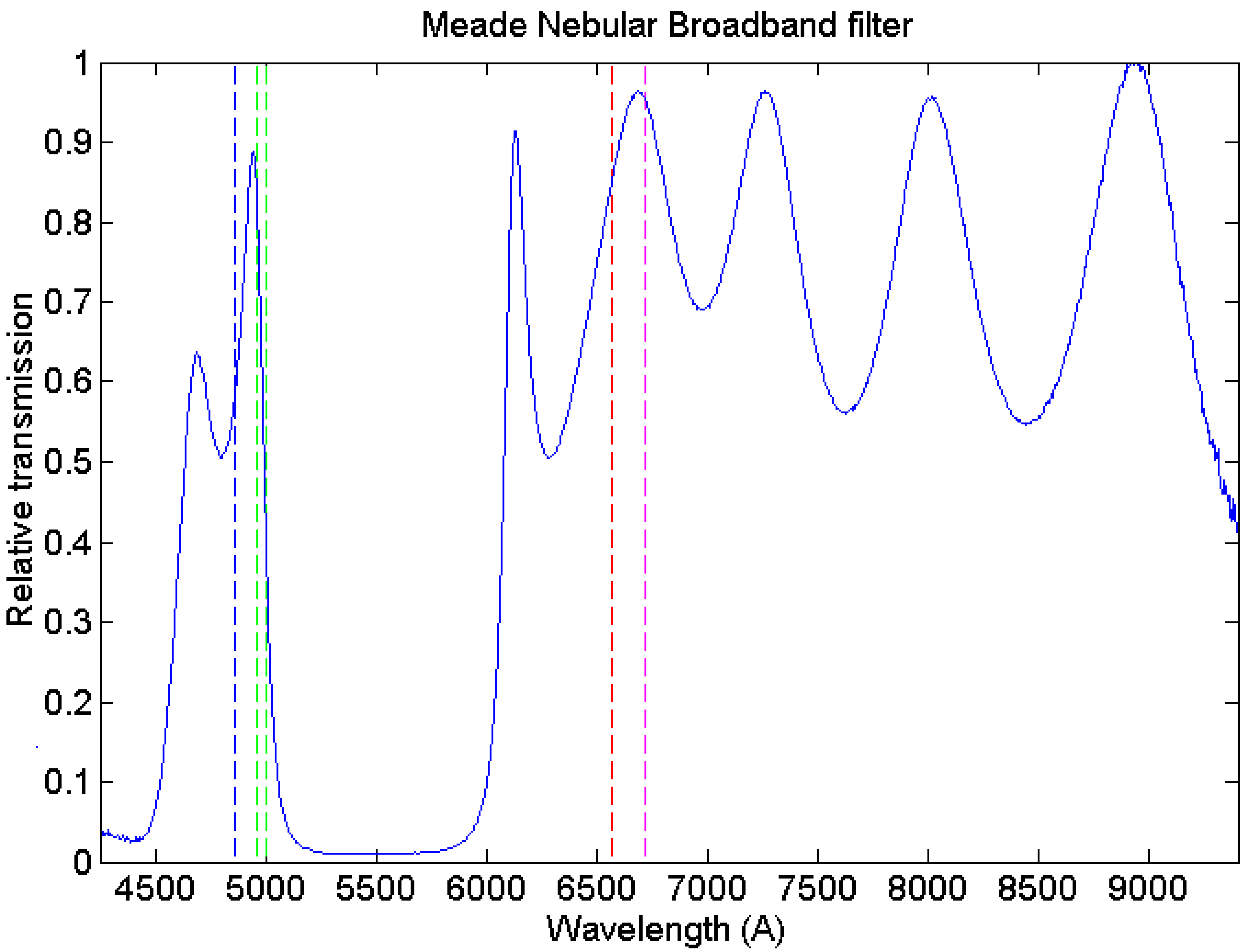
Spectral transmission of the Lumicon UHC filter.



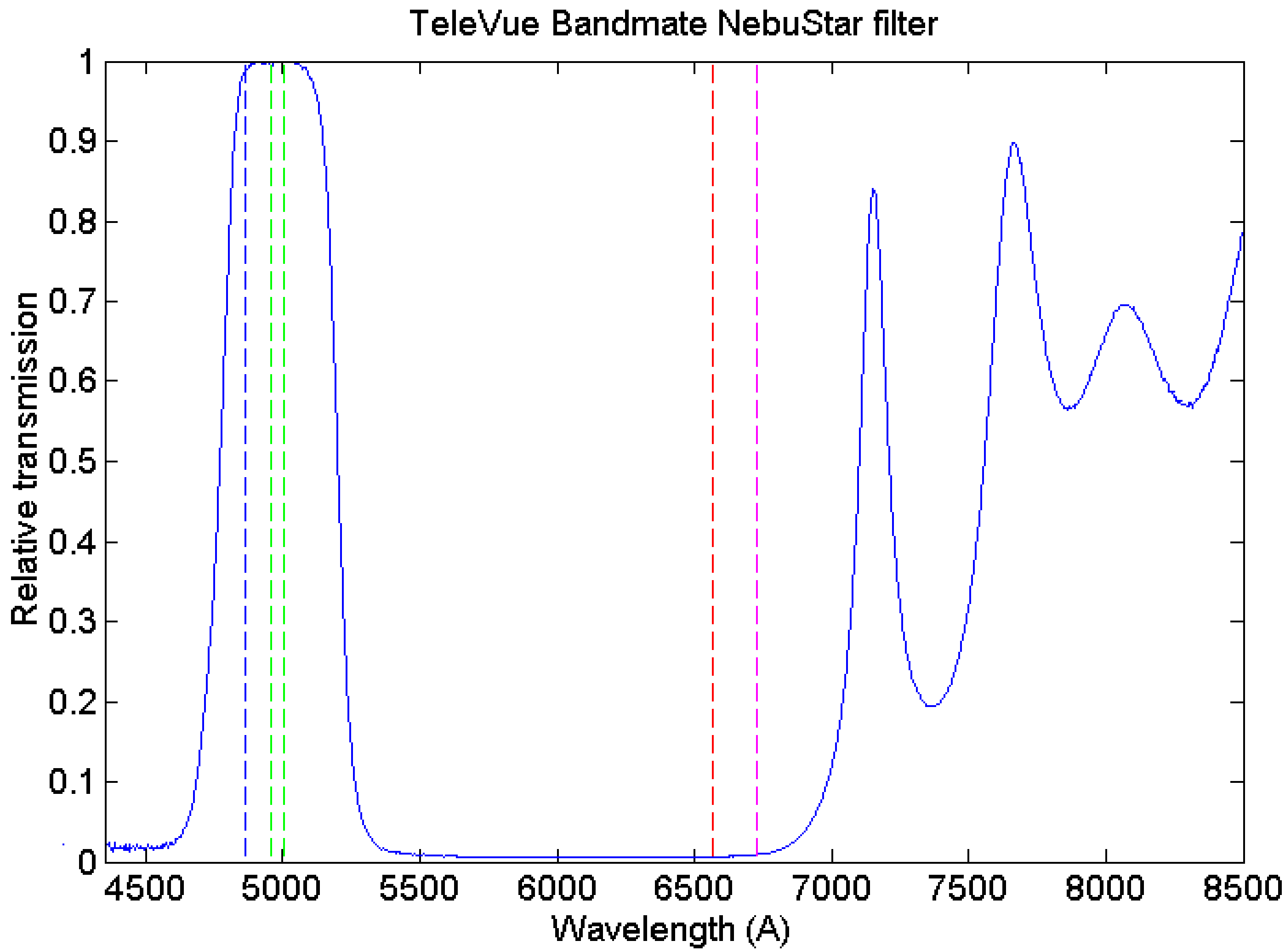
Detail of the spectral transmission of the Lumicon UHC.



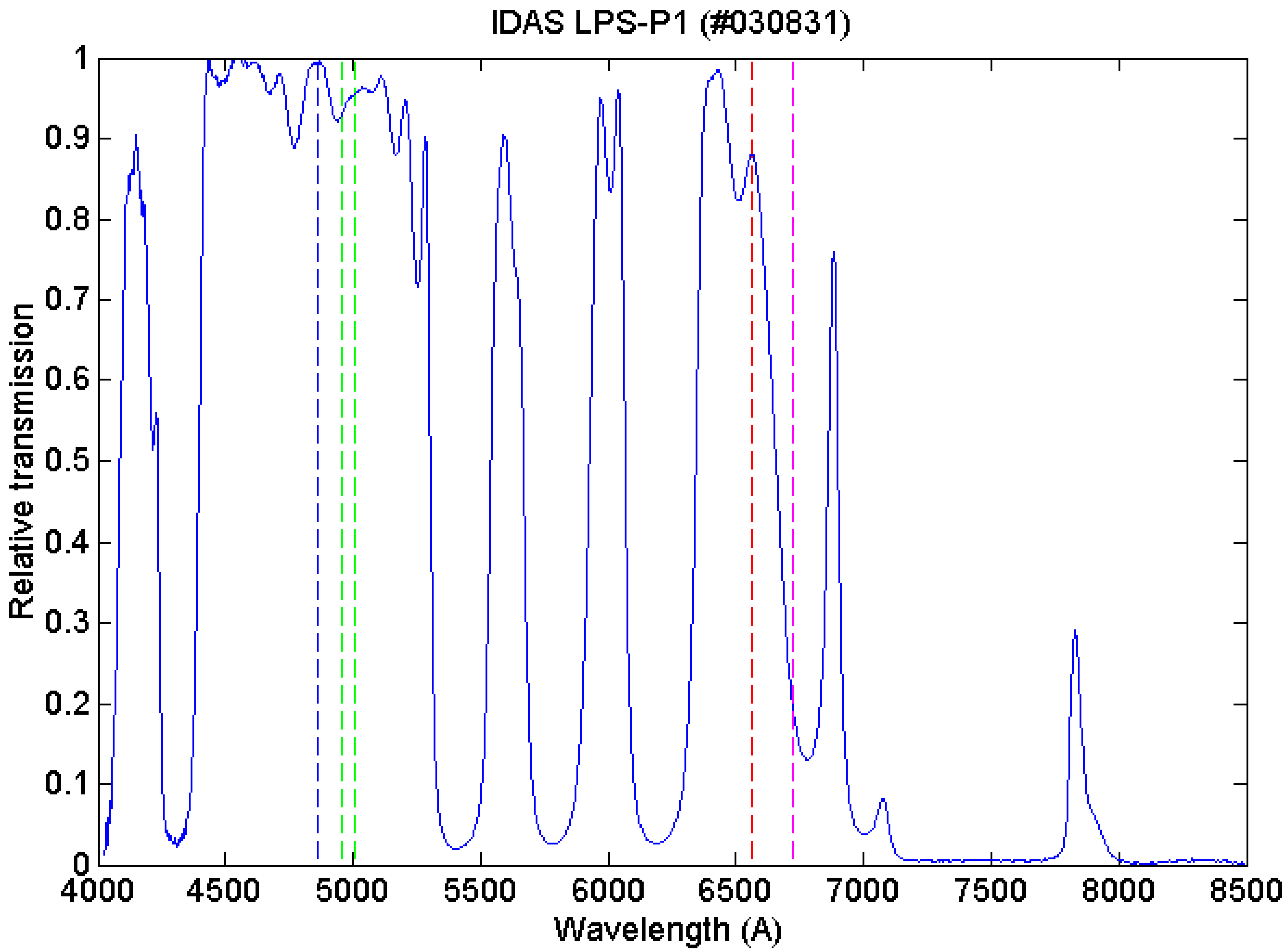
The Baader UHC-S spectral transmission.



The Meade Nebular Broadband filter spectral transmission.

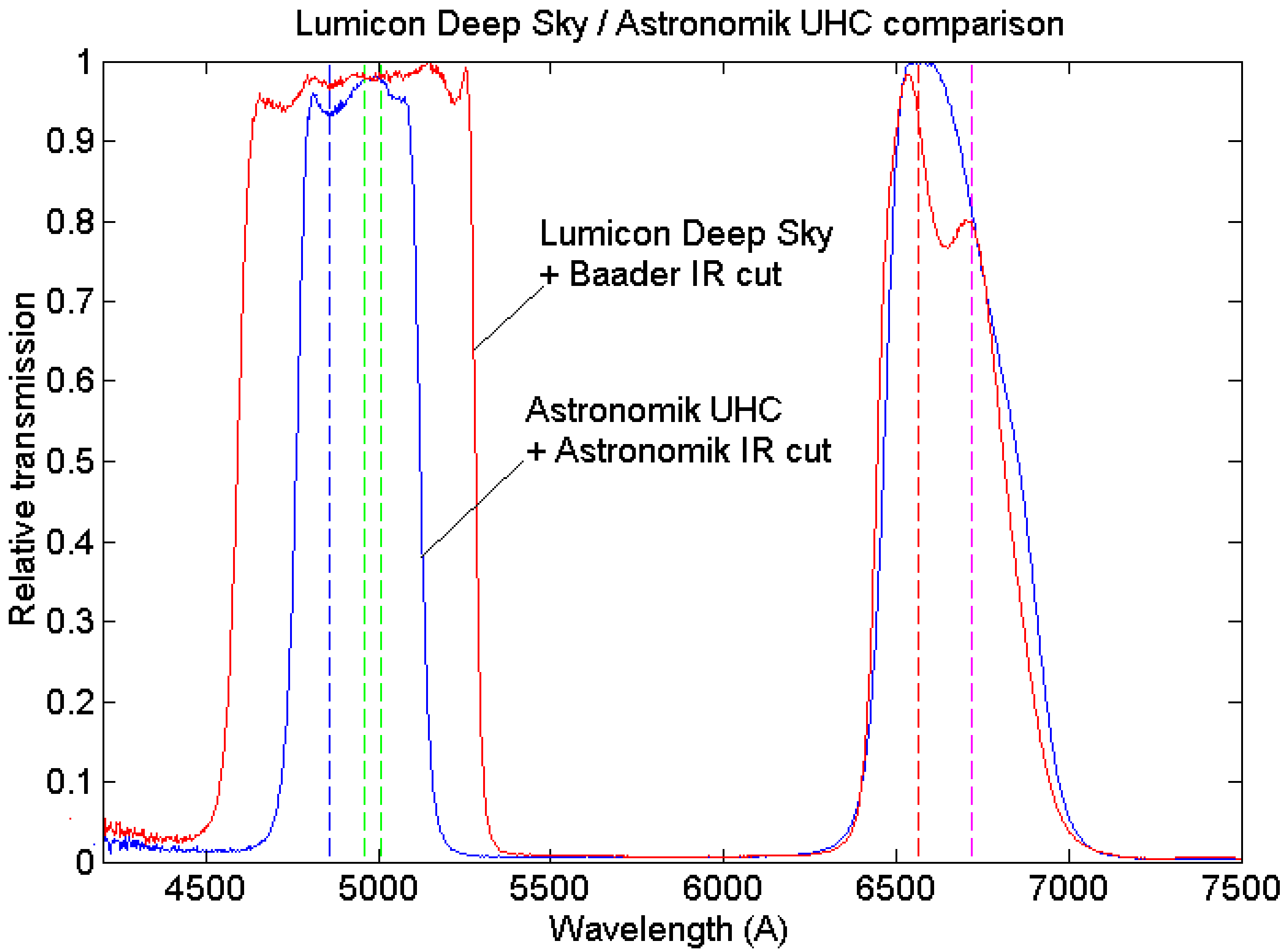


The transmission curve of a TeleVue NebuStar filter.

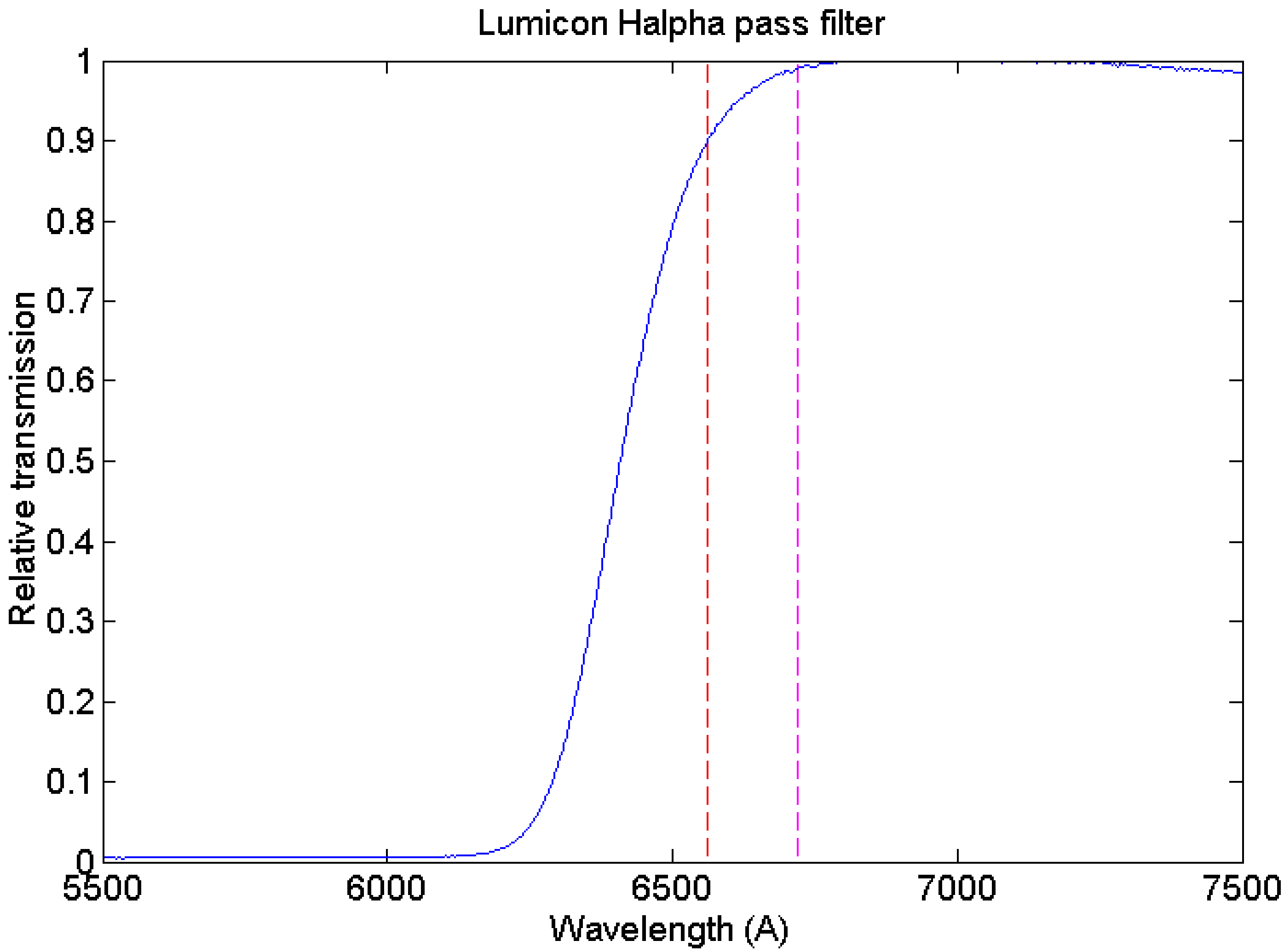


The transmission curve of a IDAS LPS-P1 filter. The transmission curve of the tested filter is globally shifted toward the blue by about 50 angstroms relative to the given constructor spectral curve. The Halpha position is indicated by the vertical dashed red line.

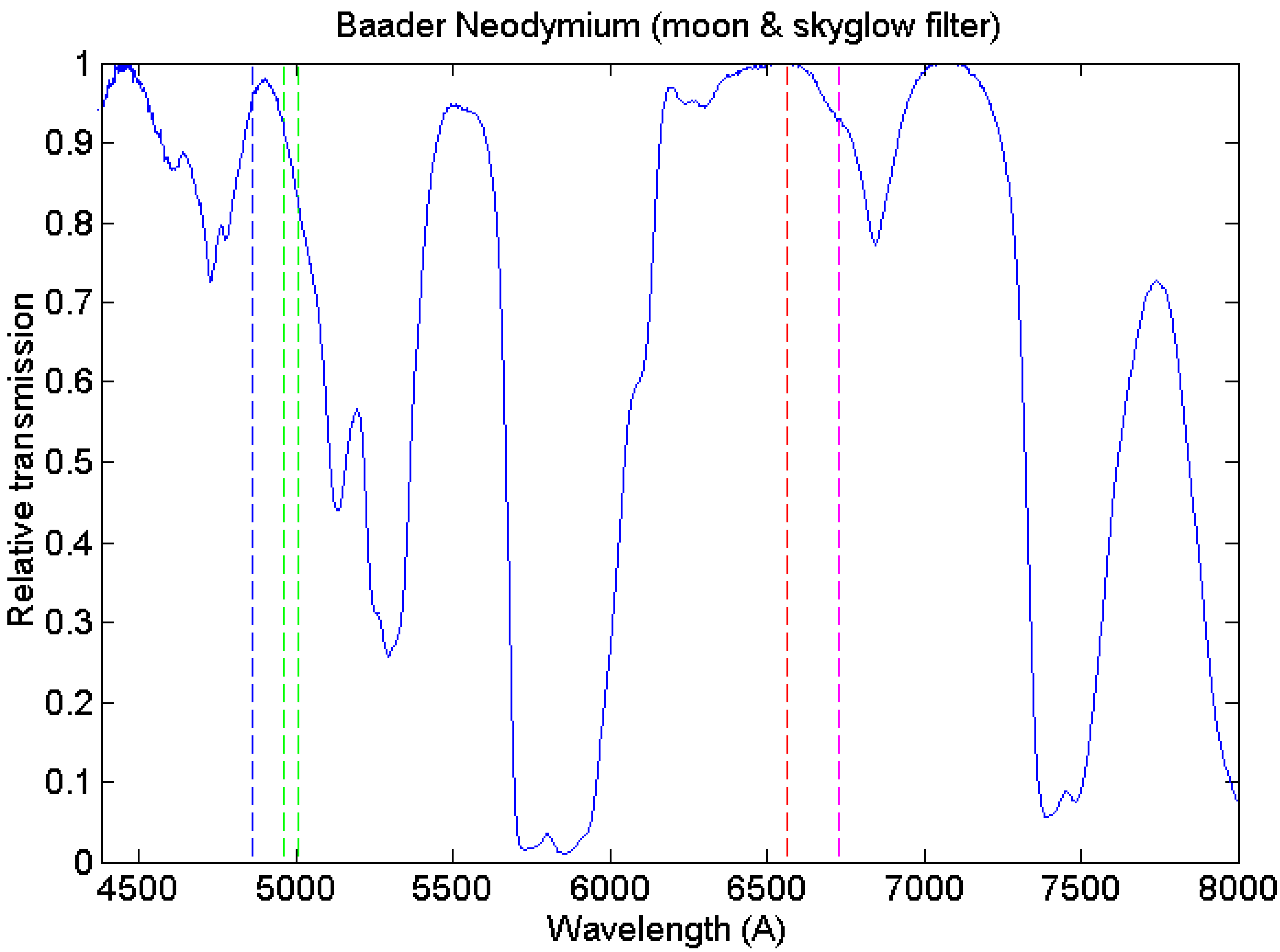
Several verification have been done to avoid possible errors. Here for checking the measure, the quasi simultaneous observation of the IDAS transmission (the source is a halogen lamp) and of the neon gases emission.



Examples of pollution rejection filter and IR cutoff filter combined. In the sense of nebula imagery only, the Astronomik solution is better because the bleue band pass is narrower (better rejection of pollution). Click here for some examples of use.

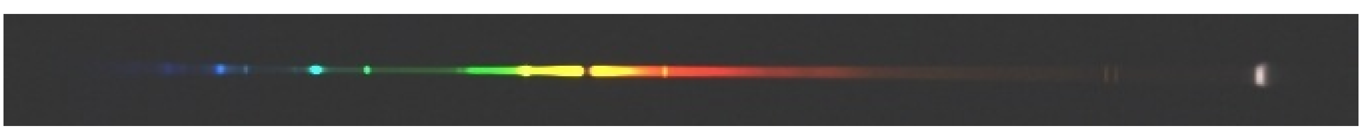


The Lumicon Halpha Pass filter. From left to right the dashed lines indicates the position of $H\alpha$ (red) and [SII] doublet (cyan).

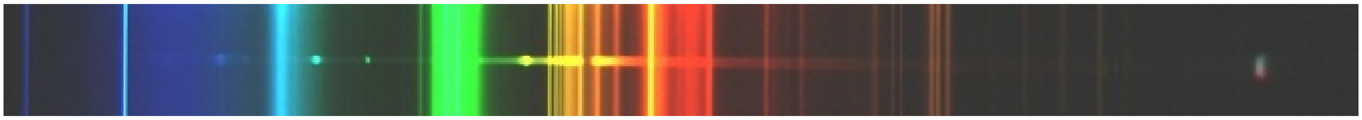


The spectral transmission of the Baader Neodymium (Moon and Skyglow filter).

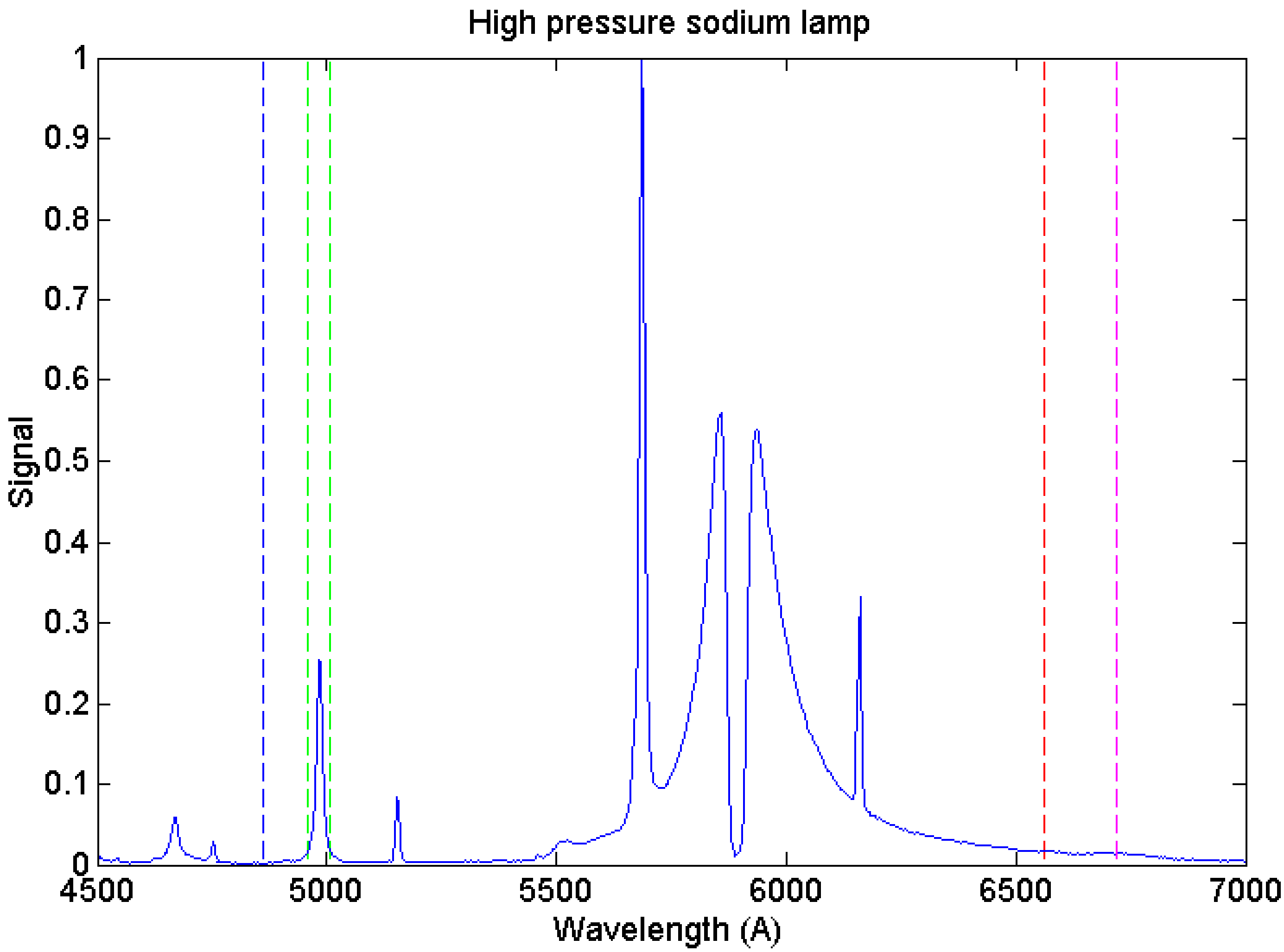
LIGHT POLLUTION REJECTION POWER



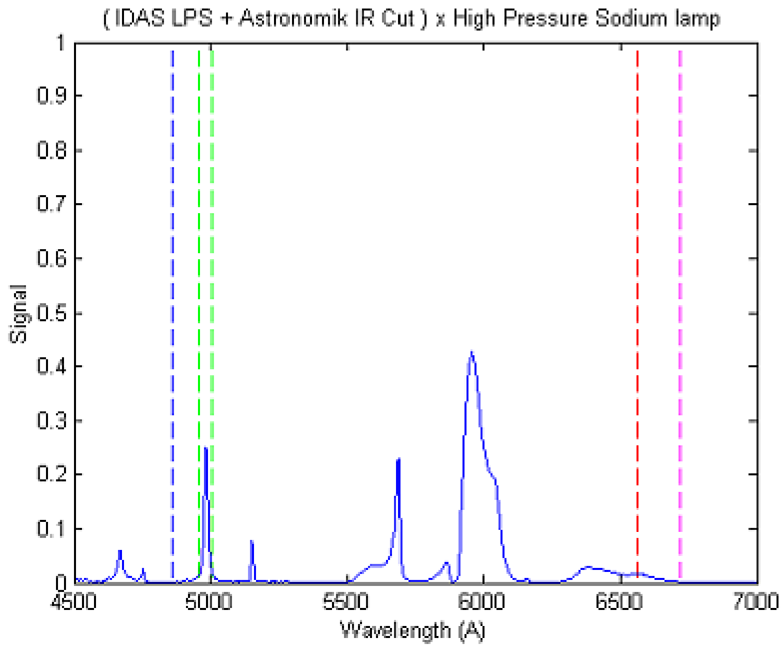
Spectral distribution of my artificial street light, dominated by the sodium (click here for explanations about the content of this spectrum). LISA spectrograph and Canon 350D are used.

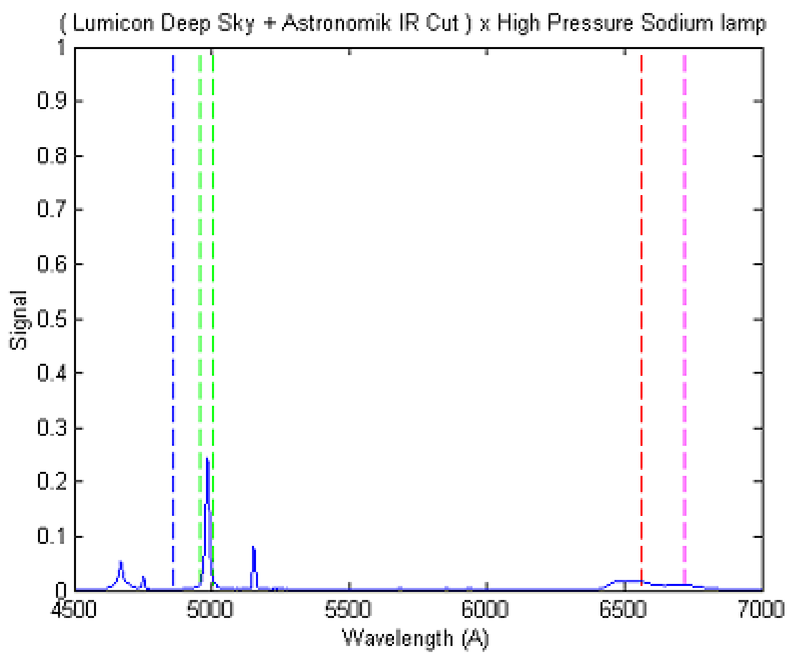


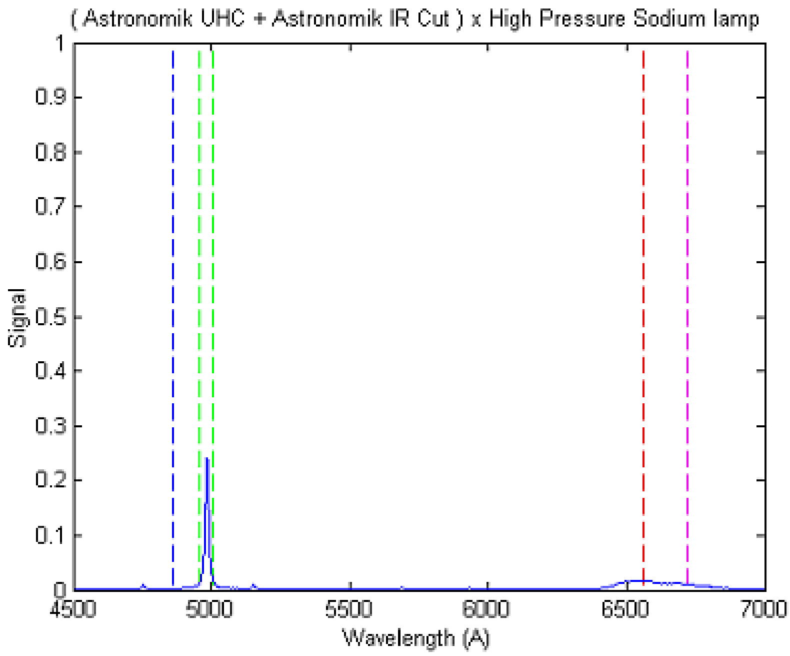
The light of an OSRAM hand poked lamp (fluorescent tube) is added. The spectrum show for example useful Hg lines for a precise spectral calibration. It is one of the emission line lamp used for this studies.



Response of the modified Canon 350 and of the spectrograph to light of a HPS lamp.


(IDAS LPS + Astronomik IR Cut) x High Pressure Sodium lamp
Signal
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
4500
5000
5500
6000
6500
7000
Wavelength (A)


(Lumicon Deep Sky + Astronomik IR Cut) x High Pressure Sodium lamp
Signal
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
4500
5000
5500
6000
6500
7000
Wavelength (A)



The HPS lamp observed through some LPR filters. The selected filters permit to observe simultaneously Halpha, Hbeta, OIII lines and SII with a DSLR sensor. From left to right, IDAS LPS-P1, Lumicon Deep Sky, Astronomik UHC. The rejection power of the IDAS filter is relatively poor. The Astronomik UHC is the better filter tested here in the sense of nebulae observation under severe light pollution with a DSLR camera (and for capture in one shot the major nebulae emission lines). Only the Na doublet (4978 and 4983 angstroms) is present. The Lumicon Deep Sky is only slightly inferior.

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