Internal Memorandum

To : G. Monnet
From : S. Zaggia, L. da Costa, A. Renzini
CC : D. Baade, S. D'Odorico, K. Meisenheimer (MPI)

June 1, 1999

Subject : **Broadband filters for the WFI**

1. Abstract.

We propose to complement the current set of filters available at the WFI by three additional filters (UBI) as described below. These new filters together with those already available will provide two sets of optical filters more appropriate for extragalactic and/or stellar studies. Our request is based on an analysis of the characteristics of the present set of WFI broadband filters and follows the recommendations from the Working Group for Public Surveys.

1. The current set of broadband filters at the WFI.

The set of broadband filters presently mounted at the WFI consists of the following filters: U (#841), B (#842), V (#843), R (#844), I (#845). The transmission curves of these filters are shown in figures 1 and 2 where they are compared with the corresponding Johnson and Cousins pass-bands. The U band filter is not shown since we still do not have the characteristics of this filter which has recently been delivered at La Silla.

In the following we report on the characteristics of each filter, their color term analysis and their usefulness for stellar and/or extragalactic studies. We based our color term analysis on the preliminary reduction of Landolt (1992) calibration fields obtained by the EIS team at the 2.2+WFI (results are presented on figure 3). We have also computed synthetic color terms, using the transmission curves in figure 1 and 2, to cross check our results (see figure 4).

- **U-band (#841)**. The specifications of U band filter are currently not available since the filter originally delivered by the manufacturer and installed during the commissioning phase was discovered to have a serious red-leak: this filter has been re-manufactured and is now at La Silla. According to the WFI manual, this U filter should be similar to the Stroemgren u-band filter with a FWHM$\simeq$ 55 nm. This is significantly narrower than a Johnson U and the Public Survey Working Group (WG) has recommended the use of broader U-band filter better suited for extragalactic studies.
- **B-band (#842)**. The WFI B filter transmission curve, convolved with the CCD efficiency, is shown in figure 1 and compared with B Johnson. This filter shows a large deviation from a standard Johnson B filter. The mean wavelength is $\simeq$ 459.0 nm which is significantly shifted to the red compared to a typical $\sim$ 430 nm for a Johnson B filter. This mismatch explains the

large color term obtained for this filter both observationally (figure 3) and with simulations (figure 4). While this filter shows good characteristics for extragalactic work (it has no red or blue tails and avoids the 400 nm range), the large color term makes it inadequate for stellar studies, where the photometry of stars are normally compared with existing photometries or with theoretical tracks tuned for standard filters. The adoption of a bluer filter is also recommended by the WG.

- **V-band (#843)**. The transmission curve of this interferometric V band filter (figure 1) shows a good match of the Johnson V filter. The sharp cut-off at $\sim$ 590 nm does not introduce a very high color term (see figure 3 and 4). Considering its very high efficiency, this filter is a good choice for both stellar and extragalactic studies.

- **R-band (#844)**. The R filter transmission curve (figure 2) shows a relatively good match with the Cousins R filter with a sharp cut-off at $\sim$ 740 nm. No observed color term is available in this case. The synthetic color term is almost zero (see figure 4). Also in this case the very high efficiency of this filter combined with its broad width and sharp cut-off at both red and blue wavelengths make it a very good choice for both stellar and extragalactic studies.

- **I-band (#845)**. The transmission curve of the I band filter (figure 2) is similar to the Johnson I filter but with a lower sensitivity beyond $\sim$ 820 nm due to the sharp decrease in the efficiency of the CCDs. The color term obtained is typical for this pass-band (see figure 3 and 4). Even though adequate for stellar work, the WG has strongly recommended the use of a filter similar to the I band filter used with EMMI in the EIS-Wide survey (close to Cousins I but with a broader transmission and higher efficiency, see figure figure 2).

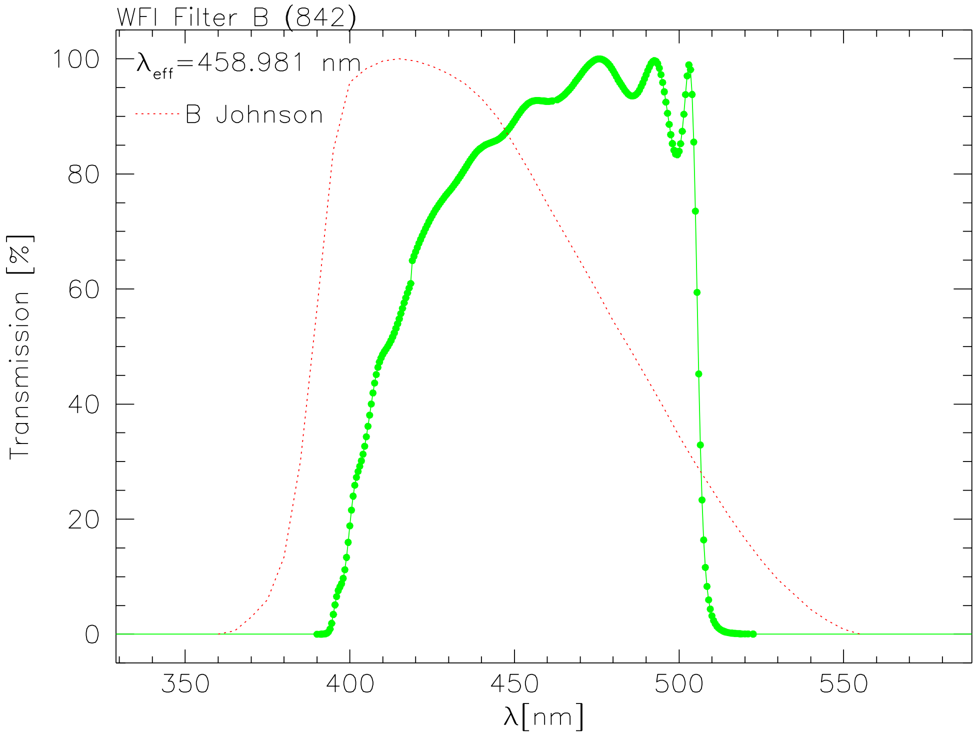
2. Summary.

In the following table we summarize the requirements for the proposed filters.

Filter	System	Cent. Wavel.	FWHM	Peak Tr.	Comments
U	Johnson	365 nm	70 nm	$\geq$ 90%	
B	Johnson	435 nm	100 nm	$\geq$ 90%	
I-wide	Cousins	820 nm	170 nm	$\geq$ 90%	Similar to EIS Wide.

For the U band filter K. Meisenheimer has already contacted OMEGA OPTICAL and received a possible technical solution. The proposed transmission curve is shown in the top panel of figure 5 where we can see that it is very similar to a Johnson U. In the bottom panel of figure 5 we also show the desired transmission curve for the B filter such that convolved with the CCD efficiency will yield the closest response to a standard Johnson B.

Finally, in the top panel of figure 6 we show the comparison of the proposed I-wide response function (a filter similar to the WB829/797 used at the NTT+EMMI for the EIS-wide survey) with the standard Cousins I. As can be seen the response is significantly broader as requested by the WG. We note that the total efficiency of the WB829/797 mounted on the WFI+2.2m is considerably higher than that obtained using it at EMMI+NTT, as shown in bottom panel of figure 6. The use of this filter will considerably improve the performance of the envisioned Public Survey.



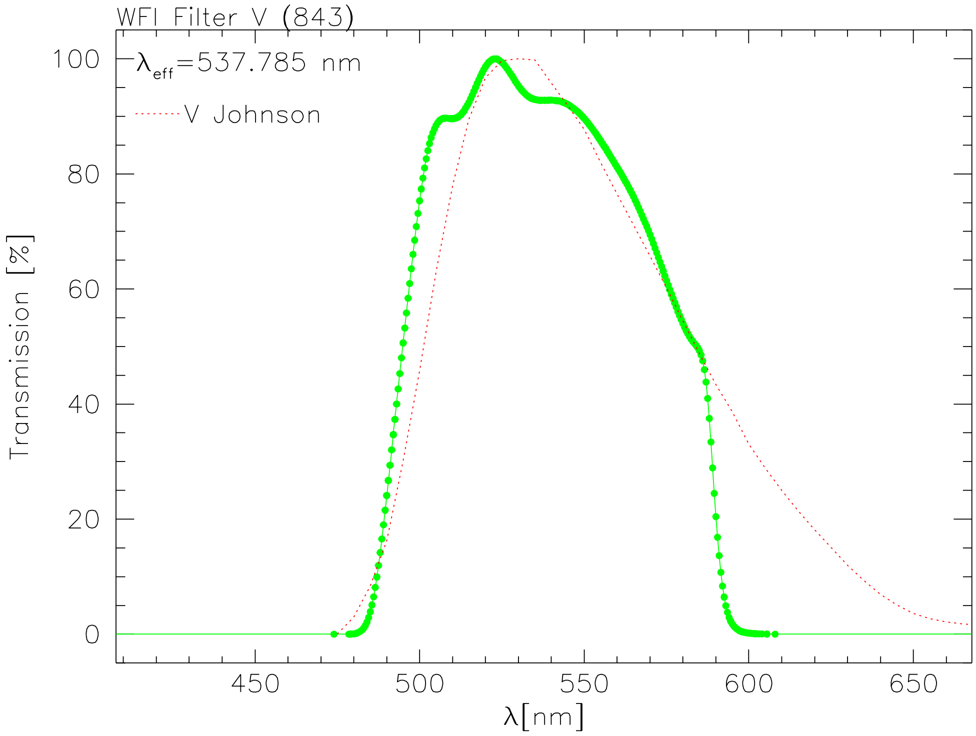


Figure 1: Comparison of WFI filter transmission curves (green continuous line) convolved with the CCD efficiency curve and normalized to 100 at peak with the corresponding Johnson (red dotted line) transmission curves. Top panel B filter, bottom panel V filter.

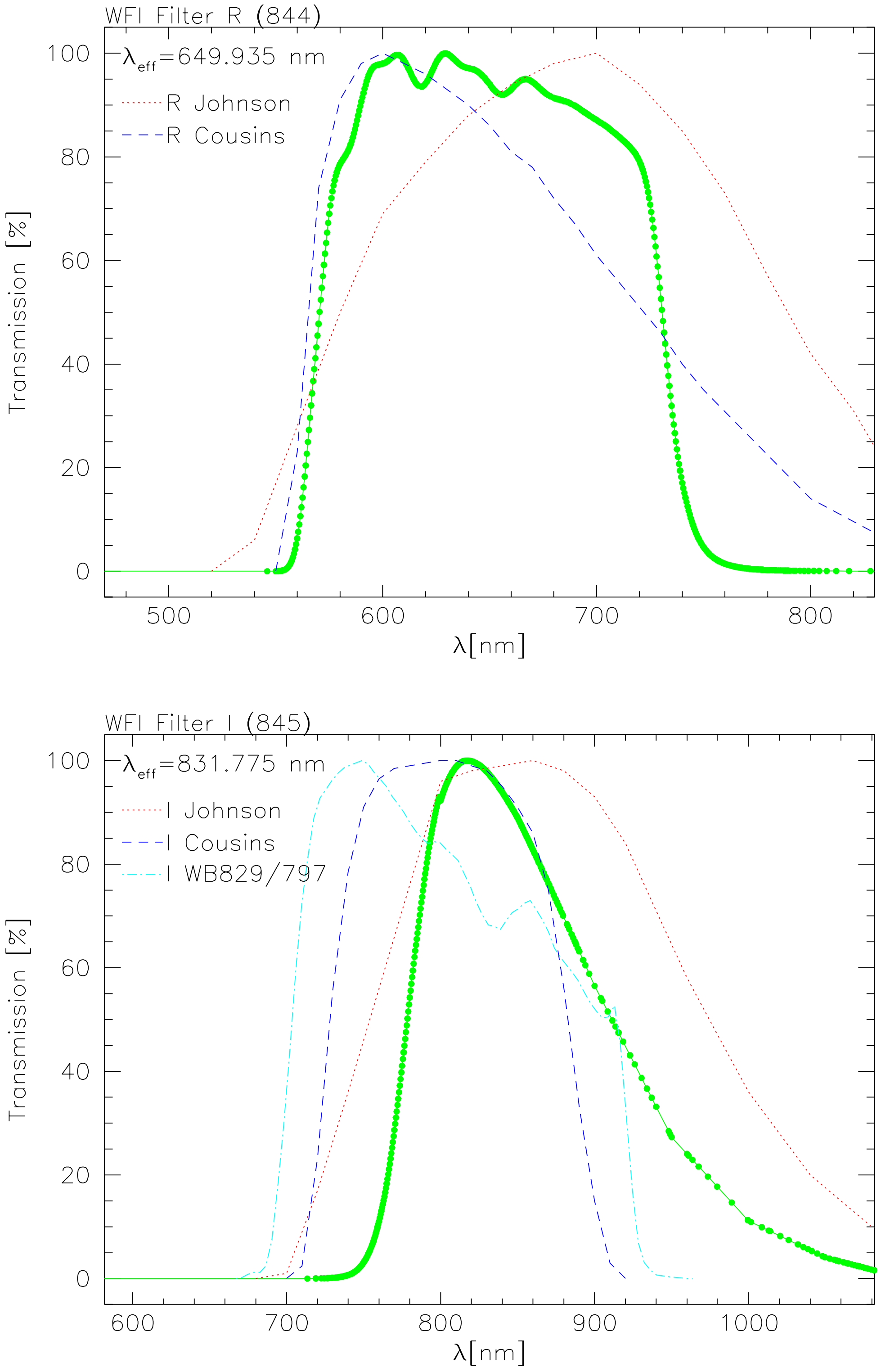


Figure 2: Comparison of WFI filter transmission curves (green continuous line) convolved with the CCD efficiency curve and normalized to 100 at peak with the corresponding Johnson (red dotted line) and Cousins (blue dashed line) transmission curves. Top panel R filter, bottom panel I filter. For the I band it is also shown the transmission curve of the filter WB829/797 (cyan dashed-dotted line) used at EMMI for the EIS Wide survey.

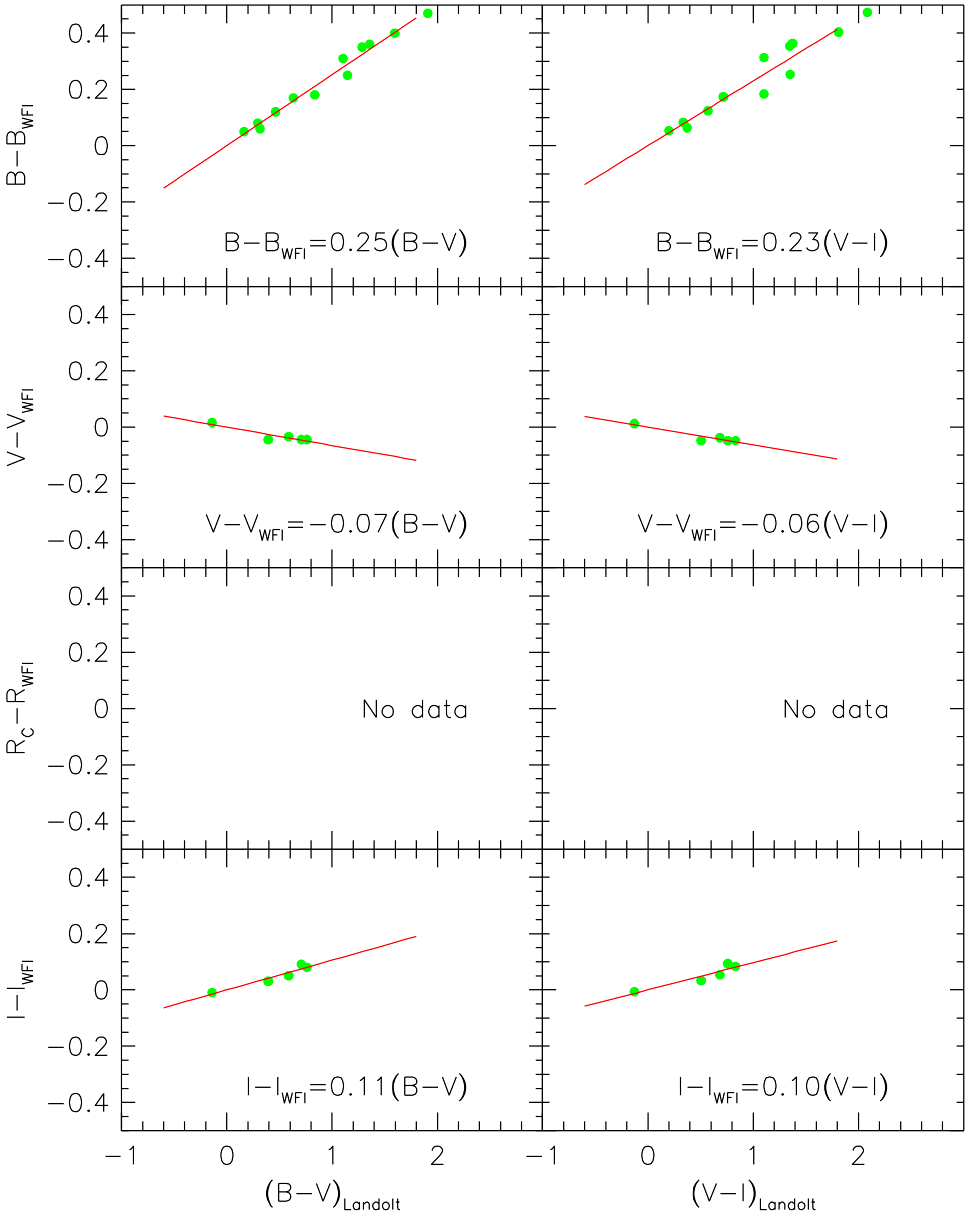


Figure 3: Observed color terms in the B, V and I WFI filters. Only data for the WFI CCD#5 are plotted. On the left column the calibration of B, V, R, and I filters (from top to bottom) band against the (B-V) color; on the right column the calibration of B, V, R, and I filters (from top to bottom) against the (V-I) color. The B data are for stars in the Selected Area 98, while for the V and I filters the data are for stars in the PG1323-086 field. In each panel it is also reported the formal fit to the calibration data.

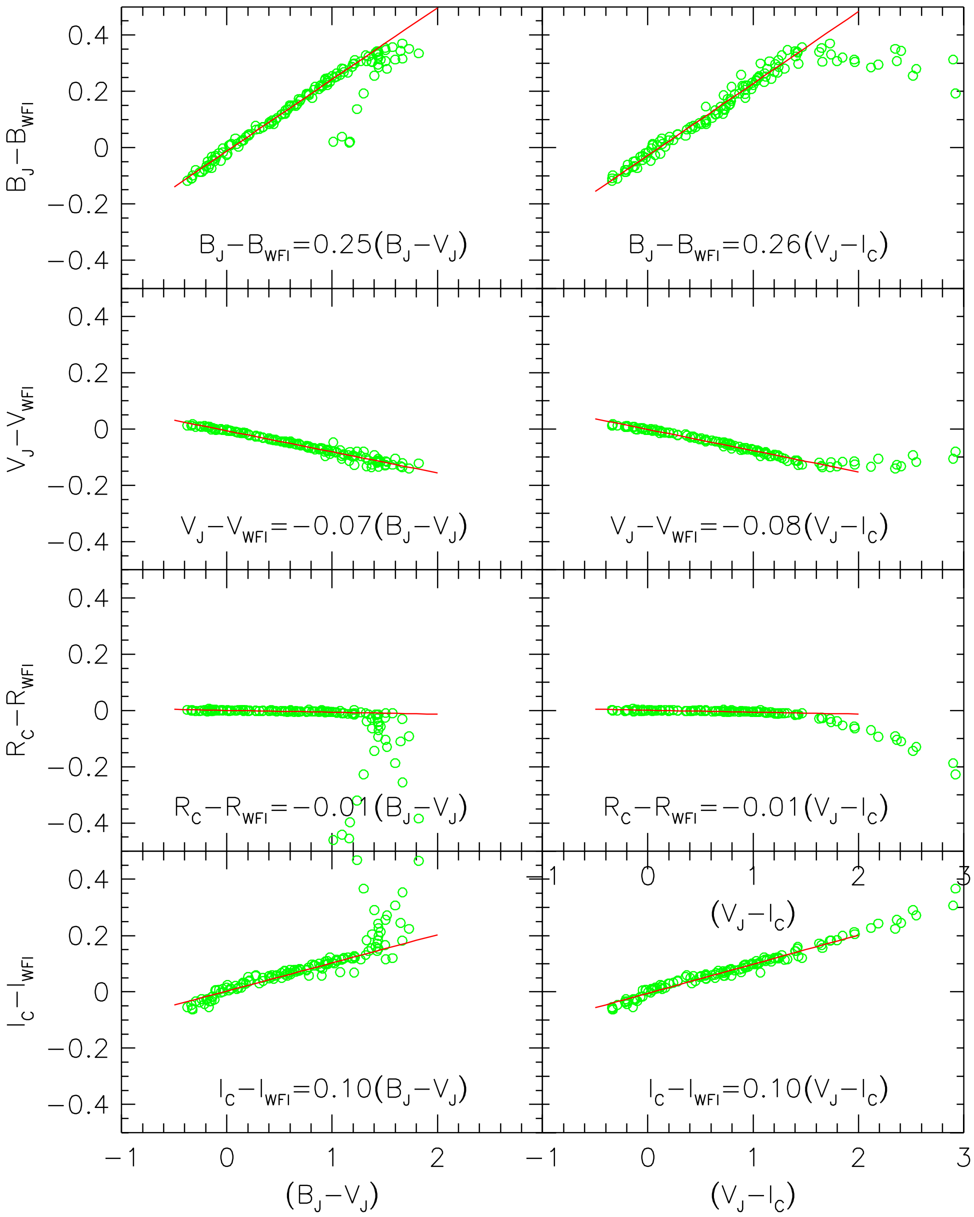


Figure 4: Simulated color terms in the B, V, R, and I WFI filters (from top to bottom). On the left column the calibration against the (B-V) color; on the right column the same calibration against the (V-I) color. The simulations have been performed computing the expected magnitudes in each given filter for the Pickles (1998) set of stellar spectral flux library. For the Johnson pass-bands it has been used transmission curves taken from the literature. For the WFI we have used the filters transmission curves shown in figure 1 and 2.

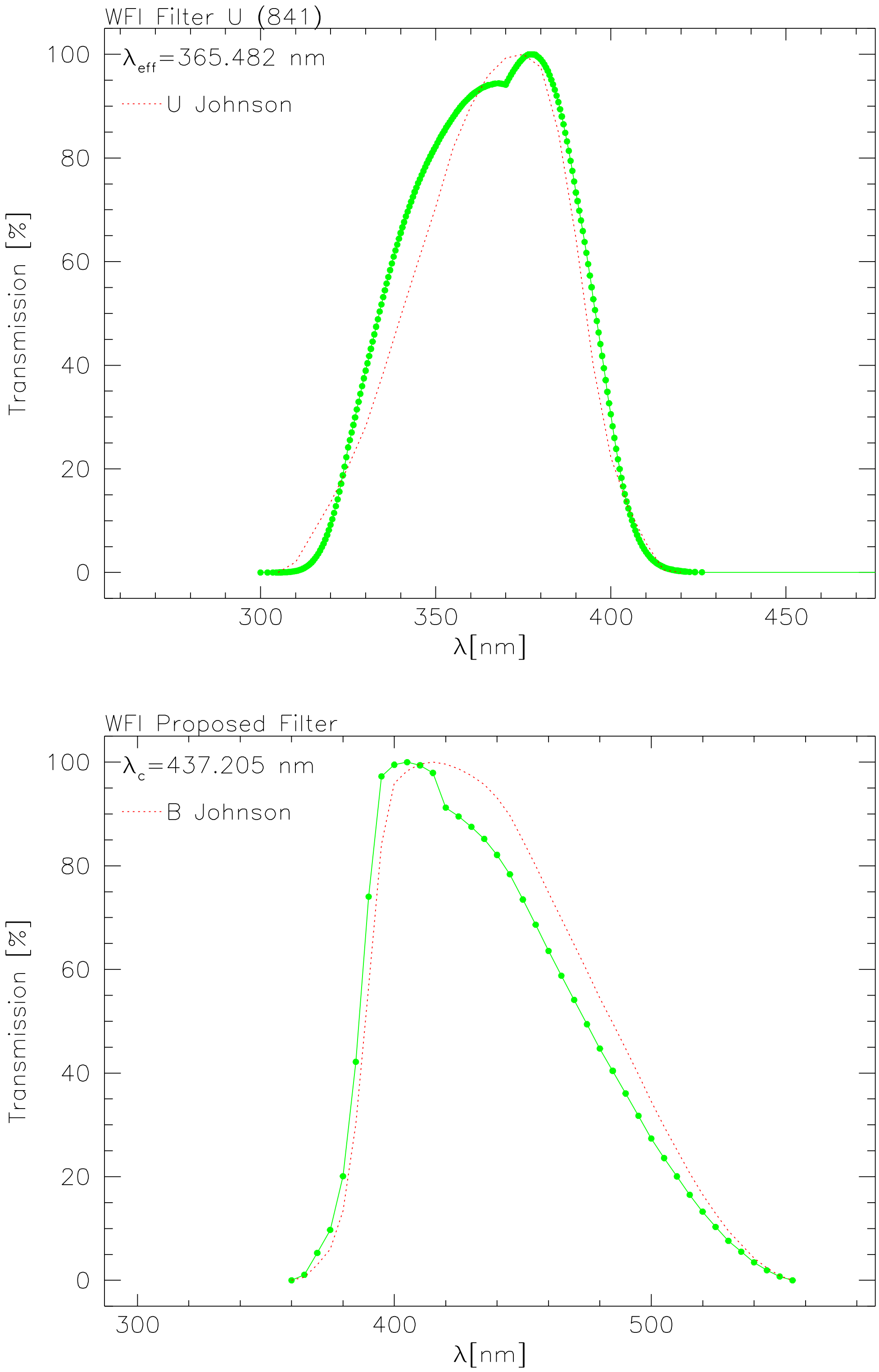


Figure 5: In both panel the green line shows a desired normalized transmission curve for the proposed U (top) and B (bottom) filters similar to the corresponding Johnson filters (red dotted line).

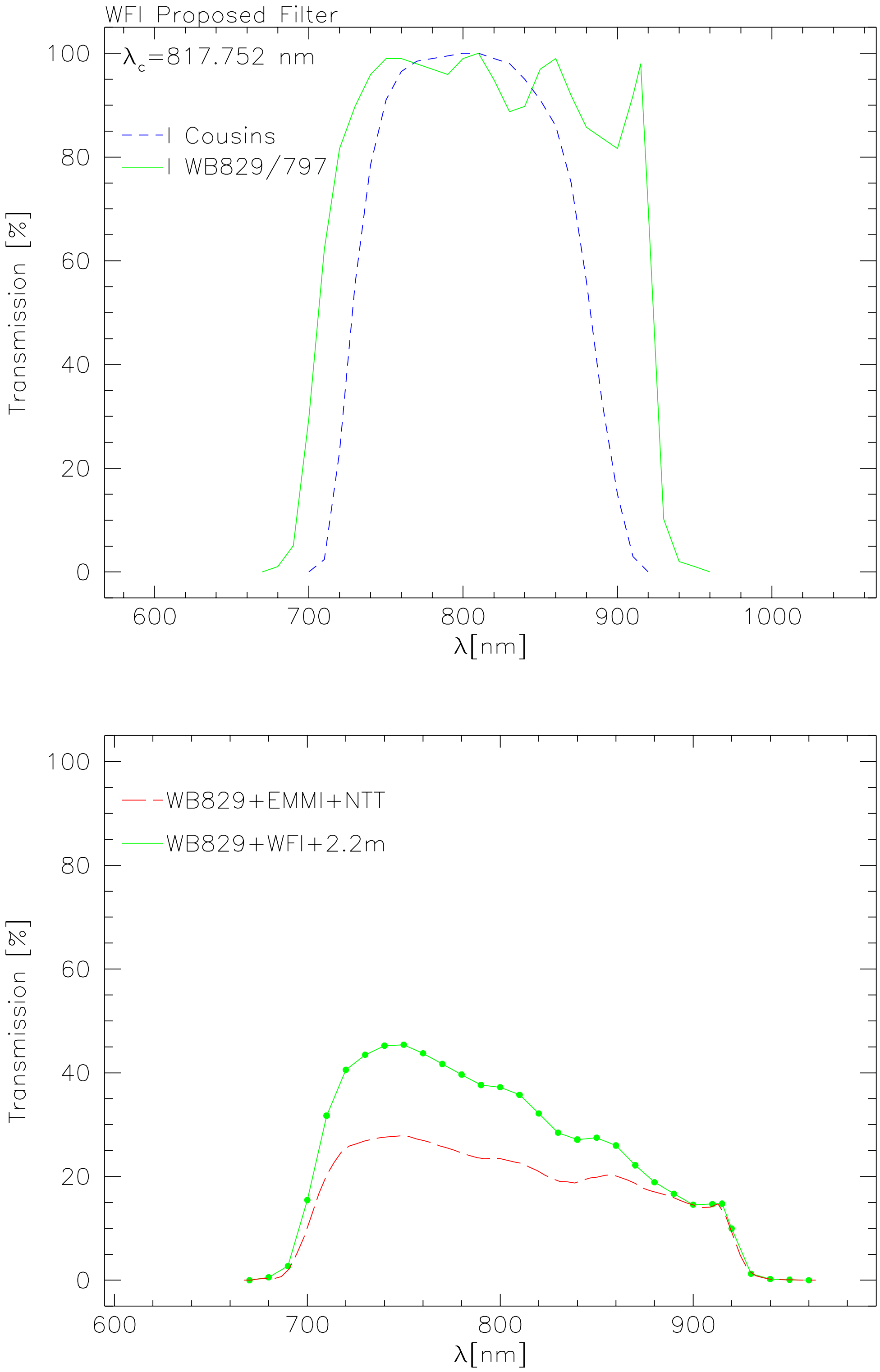


Figure 6: In both panel the green line shows the desired normalized transmission curve of the requested I filter (top panel), which transmission curve can be similar to the WB829/797 adopted at the NTT+EMMI. In the same panel it is also shown the Cousins I pass-band (blue dashed line) for comparison. In the bottom panel we show the comparison of the total efficiency of the WB829/797+WFI+2.2m (green line) with the total efficiency of the WB829/797+EMMI+NTT (red dashed line).