

COLOR CORRECTION FACTORS FOR HFI

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ABSTRACT

Color correction is an important issue for the incoming Planck early papers. For the HFI data a table for unit conversions has been made available to the collaboration. The standard $\nu I_\nu = \text{constant}$ convention has been used to convert data in K_{CMB} units into MJy/sr units (see [1]). In order to compare the Planck HFI data to emission models, this convention needs to be maintained and color correction needs to be applied to the sky fluxes predicted by those models. Here, we first revisit the former convention and update the conversion factors to the latest version of the HFI spectral bandpasses (v2.01). Finally, we compute color corrections for a set of standard emission models.

1. UNIT CONVERSION FOR THE HFI DATA

The Planck HFI calibrated maps are available in K_{CMB} units. Following [1] to convert from K_{CMB} to MJy/sr we assume first the convention

$$(1) \quad \nu I_\nu = cte = \nu_c I_c$$

where ν_c is a reference central frequency for the band and I_c the intensity for this frequency.

Applying this convention to the intensity of the CMB anisotropies and integrating over the bandpass of the bolometer we obtain

$$(2) \quad \int d\nu H_\nu^b I_\nu^{CMB} = \int d\nu H_\nu^b \frac{dB_\nu}{dT} \Big|_{T_{CMB}} \Delta T = I_c \int d\nu H_\nu^b \left(\frac{\nu_c}{\nu} \right)$$

where H_ν^b is the normalized bolometer bandpass. Assuming $\Delta T = 1 \text{ K}_{CMB}$ we obtain the following unit conversion factor at the reference central frequency ν_c

$$(3) \quad U_c = \frac{\int d\nu H_\nu^b \left(\frac{\nu_c}{\nu} \right)}{\int d\nu H_\nu^b \frac{dB_\nu}{dT} \Big|_{T_{CMB}}} \times 10^{17} \text{ MJy/sr/mK}_{CMB}$$

Table 1 shows the averaged unit conversion factors for the HFI channels computed as in equation 3. Values are given for versions v1.01 and v2.01 of the HFI bolometer bandpasses (see [2]). Note that these unit conversion factors are the averaged per channel of the individual bolometer ones with an uniform weighting scheme. The values for version v1.01 are consistent with those quoted in the data status page [1].

2. COLOR CORRECTION FOR THE HFI CHANNELS

When comparing the HFI data to models of the sky emission color corrections need to be taken into account. For this work, consider that **color corrections are applied to the model** to satisfy the convention in equation 1 prior to comparison with the data. Therefore, for a given emission law, I_ν^{model} , and using the above reasoning, the color correction factor will be defined as

$$(4) \quad F_{\nu_c}^{cc} = \frac{\int d\nu H_\nu^b \left(\frac{\nu_c}{\nu} \right)}{\int d\nu H_\nu^b I_\nu^{model} / I_{\nu_c}^{model}}$$

Notice that these factors convert from flux at a reference central frequency, ν_c , to integrated flux over the bolometer bandpass following the $\nu I_\nu = cte$ convention. In this document we take as reference central frequency the nominal frequency of the channel. Thus, the color coefficients is a multiplicative factor to correct the model brightness at the reference central frequency, ν_c .

Considering version v1.01 of the HFI bandpasses, color correction factors for models of the sky emission of the form $I_\nu \propto \nu^\beta$ are given in Tables 2. For version v2.01 of the HFI bandpasses the color correction factors are given in tables 3. These color correction factors are the averaged per channel of the individual bolometer ones with an uniform weighting scheme. A comparison between the two versions is shown on figure 1.

For models of the sky emission of the form $I_\nu \propto \nu^\beta B_\nu(T_d)$ the conversion factors are shown as contour plots on figures 2 and 3. Tables for commonly used T_d and β values are given in appendix A.

TABLE 1. Averaged unit conversion factors per channel for versions v1.01 and v2.01 of the HFI banpasses.

Channel	MJy/sr/mK _{CMB} v101	MJy/sr/mK _{CMB} v201
100	0.24153801	0.24366938
143	0.36936111	0.37038544
217	0.48112759	0.48263490
353	0.28833702	0.28614463
545	0.058263786	0.058470301
857	0.0022378119	0.0023086182

TABLE 2. Color correction factors per channel for versions v1.01 of the HFI banpasses for a power law input spectrum.

Channel \ β	-2.0000000	-1.5000000	-1.0000000	-0.5000000	0.0000000	0.5000000	1.0000000	1.5000000	2.0000000
100	0.98931165	0.99589437	1.0000000	1.0016353	1.0008221	0.99759759	0.99201466	0.98414138	0.97406044
143	0.97593329	0.98908821	1.0000000	1.0085961	1.0148224	1.0186449	1.0200496	1.0190440	1.0156561
217	1.0007489	1.0014276	1.0000000	0.99648452	0.99091591	0.98334456	0.97383570	0.96246828	0.94933368
353	1.0028122	1.0024839	1.0000000	0.99542431	0.98882590	0.98027963	0.96986663	0.95767440	0.94379678
545	1.0019196	1.0022807	1.0000000	0.99516378	0.98787375	0.97824629	0.96641108	0.95250956	0.93669305
857	0.98897570	0.99570443	1.0000000	1.0018787	1.0013760	0.99854584	0.99345937	0.98620359	0.97687964

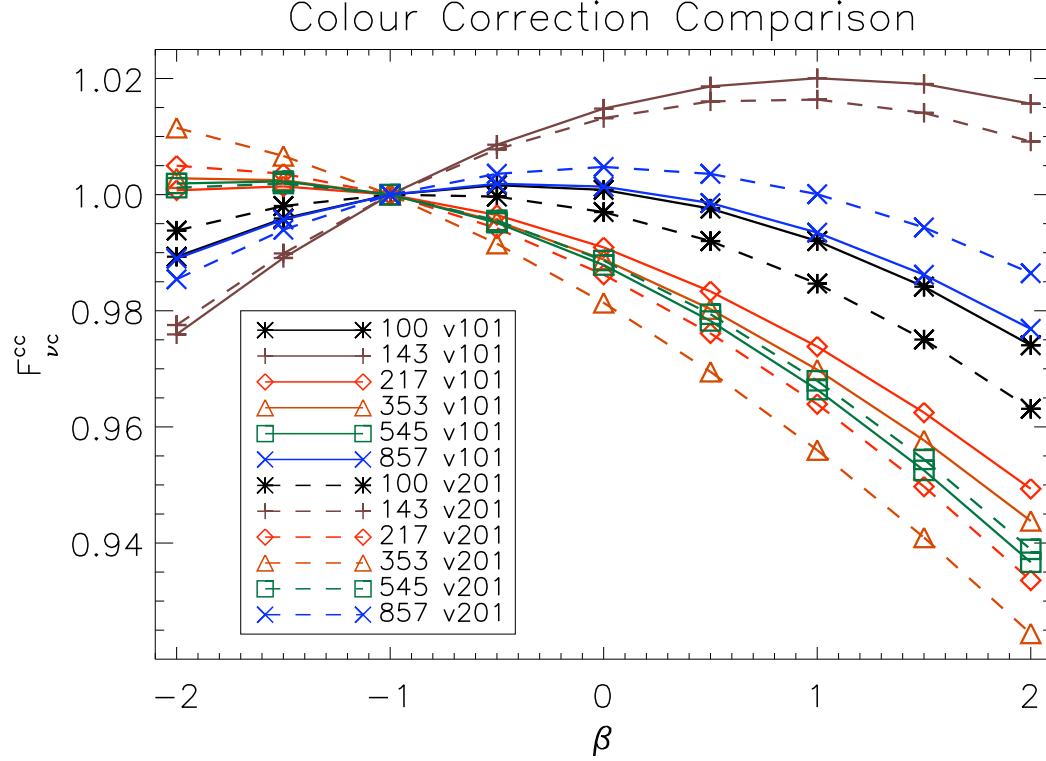


FIGURE 1. Color correction factors for v1.01 and v2.01 versions of the HFI bandpasses.

TABLE 3. Color correction factors per channel for versions v2.01 of the HFI bandpasses for a power law input spectrum.

Channel \ β	-2.0000000	-1.5000000	-1.0000000	-0.5000000	0.0000000	0.5000000	1.0000000	1.5000000	2.0000000
100	0.99381017	0.99803650	1.0000000	0.99966152	0.99699830	0.99200273	0.98467997	0.97504440	0.96311420
143	0.97754443	0.98987910	1.0000000	1.0077971	1.0131757	1.0160565	1.0163754	1.0140825	1.0091402
217	1.0049788	1.0035955	1.0000000	0.99420187	0.98622648	0.97611444	0.96392046	0.94971189	0.93356703
353	1.0115100	1.0066627	1.0000000	0.99155448	0.98136924	0.96949712	0.95599969	0.94094610	0.92441176
545	1.0011907	1.0019063	1.0000000	0.99555062	0.98865080	0.97940795	0.96794406	0.95439453	0.93890637
857	0.98543116	0.99395870	1.0000000	1.0035910	1.0047686	1.0035793	1.0000828	0.99435334	0.98647932

REFERENCES

- [1] G. Lagache. <http://wiki.planck.fr/index.php/proc/datastatus/>, 2010.
- [2] L. Spencer. Hfi detector spectral transmission profiles version 2.01 – report, 2010.

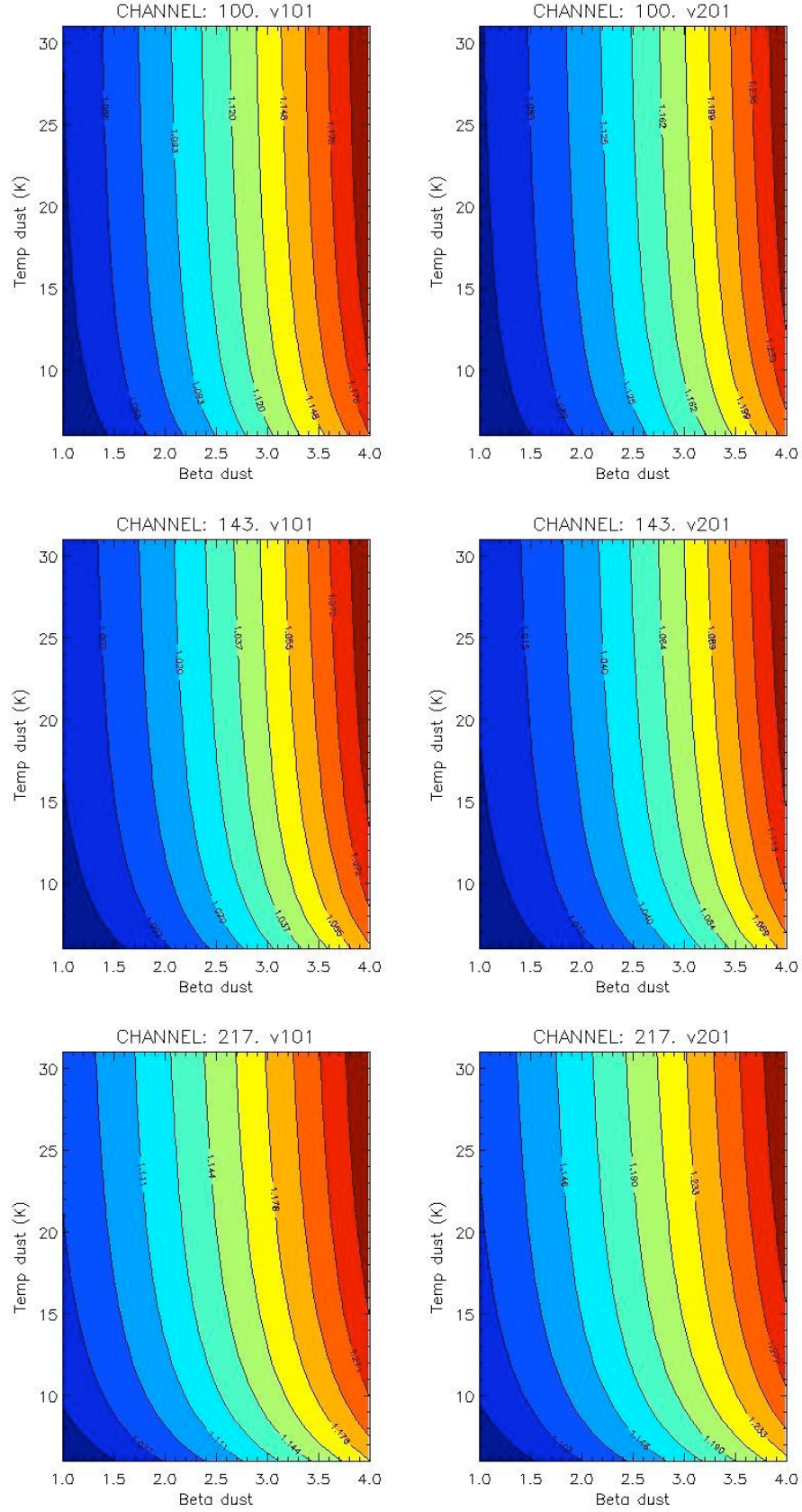


FIGURE 2. Color correction factors for a dust like model for v1.01(left) and v2.01(right) versions of the HFI bandpasses for 100, 143 and 217 GHz.

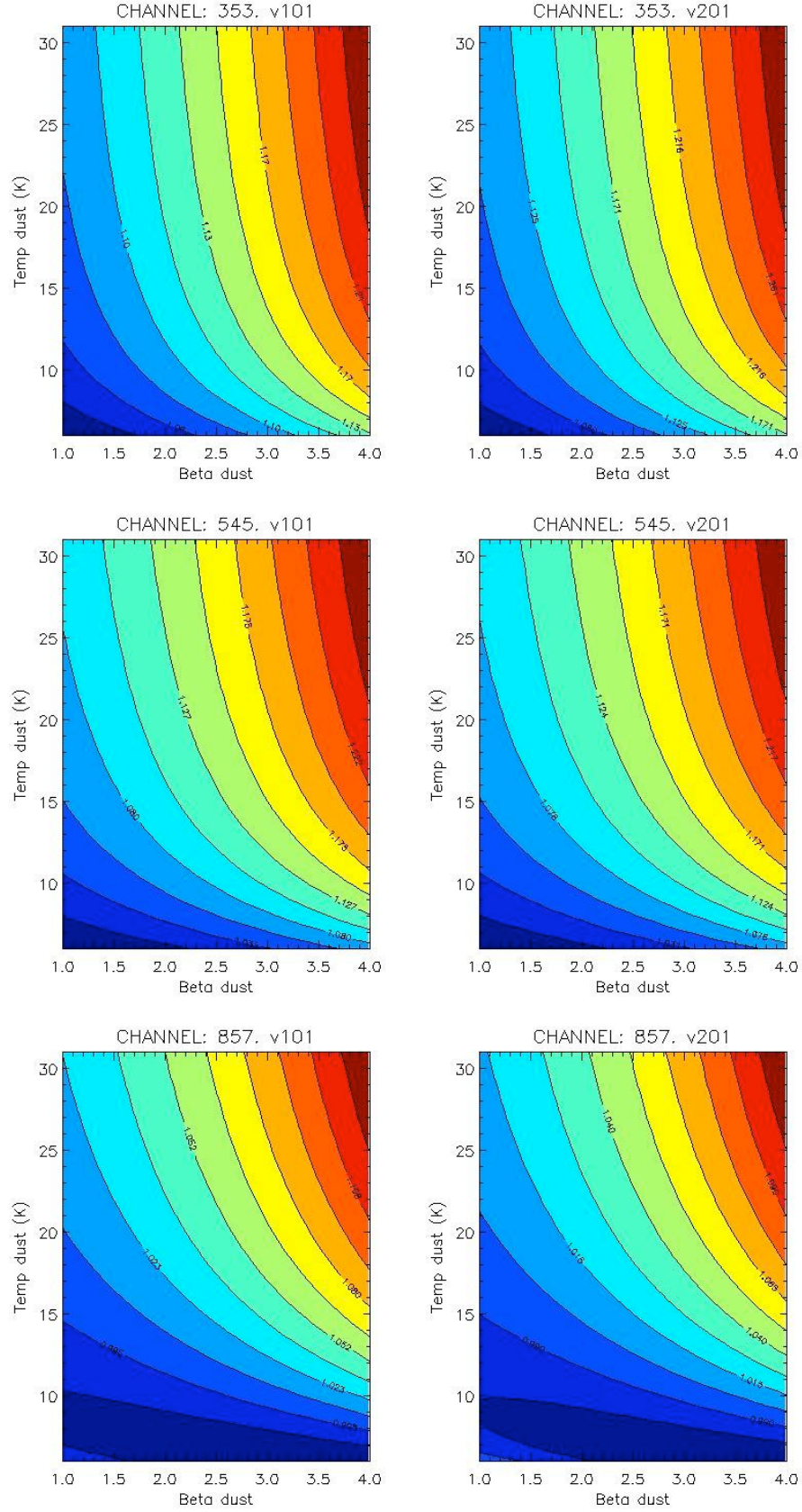


FIGURE 3. Color correction factors for a dust like model for v1.01(right) and v2.01(left) versions of the HFI bandpasses for 353, 545 and 857 GHz.

APPENDIX A. COLOR CORRECTION FACTORS FOR A DUST-LIKE MODEL OF THE SKY
SIGNAL.

TABLE 4. Colour correction for bandpass version v101 and for 100 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	0.94869165	0.93916788	0.93245843	0.91448560	0.89490923	0.87387045	0.85151337
11.00	0.94056458	0.93056216	0.92354484	0.90484307	0.88459783	0.86295177	0.84004955
16.00	0.93765984	0.92749354	0.92037097	0.90142052	0.88094780	0.85909589	0.83600955
21.00	0.93617382	0.92592502	0.91874950	0.89967402	0.87908709	0.85713198	0.83395345
26.00	0.93527204	0.92497360	0.91776622	0.89861558	0.87796004	0.85594296	0.83270914

TABLE 5. Colour correction for bandpass version v201 and for 100 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	0.93401616	0.92309972	0.91538049	0.89451423	0.87133162	0.84566497	0.81723076
11.00	0.92441800	0.91280102	0.90459561	0.88241949	0.85772964	0.83025316	0.79956320
16.00	0.92094314	0.90907021	0.90068558	0.87801981	0.85275491	0.82457490	0.79299562
21.00	0.91915616	0.90715107	0.89867359	0.87575287	0.85018647	0.82163539	0.78958521
26.00	0.91806902	0.90598334	0.89744914	0.87437231	0.84862064	0.81984087	0.78749999

TABLE 6. Colour correction for bandpass version v101 and for 143 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	1.0087689	1.0033841	0.99936150	0.98783874	0.97431247	0.95890805	0.94176205
11.00	1.0007913	0.99454444	0.98996090	0.97708861	0.96229586	0.94571607	0.92749235
16.00	0.99787670	0.99134122	0.98657031	0.97324876	0.95803649	0.94106945	0.92249276
21.00	0.99638086	0.98970174	0.98483766	0.97129300	0.95587280	0.93871422	0.91996335
26.00	0.99547289	0.98870794	0.98378821	0.97011038	0.95456620	0.93729355	0.91843906

TABLE 7. Colour correction for bandpass version v201 and for 143 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	1.0000310	0.99329761	0.98827886	0.97387527	0.95681250	0.93707510	0.91463500
11.00	0.98986573	0.98196295	0.97615534	0.95974135	0.94060041	0.91869628	0.89397539
16.00	0.98610415	0.97779382	0.97171074	0.95459233	0.93471917	0.91204690	0.88651239
21.00	0.98416438	0.97564815	0.96942579	0.95195082	0.93170638	0.90864387	0.88269527
26.00	0.98298402	0.97434378	0.96803752	0.95034764	0.92987921	0.90658107	0.88038226

TABLE 8. Colour correction for bandpass version v101 and for 217 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	0.94349454	0.93406305	0.92747162	0.90998585	0.89116086	0.87112503	0.85000982
11.00	0.92242107	0.91199343	0.90476546	0.88578800	0.86561792	0.84438732	0.82222955
16.00	0.91504316	0.90430490	0.89687939	0.87744225	0.85686235	0.83527255	0.81280640
21.00	0.91134255	0.90045483	0.89293443	0.87327712	0.85250182	0.83074169	0.80813027
26.00	0.90912768	0.89815240	0.89057647	0.87079049	0.84990128	0.82804214	0.80534659

TABLE 9. Colour correction for bandpass version v201 and for 217 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	0.92658875	0.91529520	0.90742737	0.88662137	0.86427830	0.84050696	0.81541459
11.00	0.90115894	0.88867355	0.88003122	0.85735821	0.83324261	0.80778294	0.78106948
16.00	0.89221997	0.87934893	0.87045565	0.84717564	0.82247872	0.79645704	0.76919154
21.00	0.88772855	0.87466904	0.86565304	0.84207558	0.81709254	0.79079231	0.76325043
26.00	0.88503799	0.87186716	0.86277862	0.83902520	0.81387249	0.78740646	0.75969918

TABLE 10. Colour correction for bandpass version v101 and for 353 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	0.96800363	0.95990917	0.95418844	0.93879694	0.92193087	0.90369714	0.88420702
11.00	0.93185464	0.92181041	0.91483195	0.89644932	0.87681967	0.85605897	0.83428523
16.00	0.91864281	0.90802075	0.90067198	0.88141721	0.86099399	0.83952011	0.81711462
21.00	0.91203813	0.90114743	0.89362695	0.87396936	0.85318190	0.83138303	0.80869210
26.00	0.90811461	0.89707005	0.88945137	0.86956389	0.84856927	0.82658631	0.80373444

TABLE 11. Colour correction for bandpass version v201 and for 353 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	0.95125393	0.94162021	0.93491381	0.91719419	0.89818326	0.87797225	0.85665391
11.00	0.90996266	0.89857390	0.89073167	0.87029364	0.84873755	0.82615092	0.80261773
16.00	0.89516299	0.88324186	0.87505546	0.85379377	0.83146398	0.80814863	0.78392436
21.00	0.88779807	0.87562589	0.86727711	0.84562622	0.82292929	0.79926556	0.77470707
26.00	0.88343123	0.87111405	0.86267145	0.84079542	0.81788554	0.79401884	0.76926428

TABLE 12. Colour correction for bandpass version v101 and for 545 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	1.0070239	1.0011705	0.99682409	0.98446370	0.97007849	0.95381453	0.93582613
11.00	0.95025205	0.94012019	0.93302425	0.91416574	0.89384192	0.87222052	0.84946950
16.00	0.92611947	0.91483446	0.90700860	0.88646351	0.86465286	0.84174509	0.81790653
21.00	0.91382144	0.90203435	0.89389279	0.87262560	0.85018896	0.82675061	0.80247512
26.00	0.90652273	0.89446028	0.88614622	0.86448670	0.84171321	0.81799280	0.79348877

TABLE 13. Colour correction for bandpass version v201 and for 545 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	1.0078650	1.0022576	0.99807075	0.98609128	0.97205828	0.95611558	0.93841673
11.00	0.95239894	0.94245452	0.93547766	0.91689614	0.89682003	0.87541816	0.85286019
16.00	0.92862084	0.91750344	0.90978353	0.88948339	0.86789013	0.84517381	0.82150278
21.00	0.91647965	0.90485097	0.89680935	0.87577260	0.85353983	0.83028058	0.80616155
26.00	0.90926795	0.89735870	0.88914118	0.86770398	0.84512685	0.82157872	0.79722504

TABLE 14. Colour correction for bandpass version v101 and for 857 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	1.0165642	1.0215470	1.0243932	1.0298387	1.0329007	1.0335987	1.0319704
11.00	1.0127801	1.0094169	1.0067419	0.99858342	0.98840786	0.97632984	0.96247363
16.00	0.99205883	0.98611719	0.98176576	0.96957735	0.95561957	0.94002584	0.92293504
21.00	0.97889177	0.97180886	0.96672078	0.95277975	0.93720260	0.92012869	0.90170091
26.00	0.97047869	0.96277342	0.95728522	0.94239760	0.92595341	0.90809452	0.88896525

TABLE 15. Colour correction for bandpass version v201 and for 857 channel.

$T_{\text{dust}} \text{ (K)} \setminus \beta$	1.50	1.80	2.00	2.50	3.00	3.50	4.00
6.00	1.0122763	1.0182442	1.0217556	1.0288854	1.0336486	1.0360467	1.0361003
11.00	1.0185148	1.0161068	1.0140566	1.0074120	0.99867091	0.98793679	0.97532433
16.00	1.0009589	0.99588068	0.99208750	0.98122897	0.96849983	0.95402592	0.93794041
21.00	0.98918744	0.98291216	0.97834303	0.96562711	0.95116601	0.93509340	0.91754823
26.00	0.98153162	0.97459908	0.96960550	0.95587904	0.94048330	0.92355550	0.90523707