Release Note for ISOPHOT OLP Version 8.4 [1]

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[1] This release note is an excerpt of the first 2 chapters from the document "Report on the PHT Scientific Validation for OLP Version 8.4 (SAI/1999-041/Rp, Version 1.0, 06-August-1999).

Contents

Chapter 1

Results and Achievements by PHT OLP V8.4 Scientific Validation

1.1 Calibration Upgrades from OLP7 to OLP8

In Table 1.1 we list the major calibration upgrades which were implemented for OLP8 and describe which AOTs or AOT submodes were affected by the individual upgrades. There are two calibration upgrades which are part of the formal OLP/CALG delivery, but which are standalone and are not used by the OLP processing. THey are or can be used in the Interactive Analysis environment.

Table 1.1: Calibration upgrades from OLP 7 to OLP 8.4 and impact on the different AOT modes

	calibration upgrade	**affects AOT**
1)	flux dependent signal linearization	all AOTs, except PHT40
2)	FCS characterisation	all AOTs, except PHT40
3)	signal derivation and photometric calibration of chopped measurements	PHT03, PHT22 in chopped mode
4)	PSF factors for PHT-C arrays & pixels	PHT22, PHT25, PHT37/38/39
5)	relative spectral response function for chopped PHT-S measurements	PHT40 in chopped mode
6)	solid angle for PHT-S aperture	PHT40 extended sources
7)	footprint matrixes (not used by OLP, not available for P1)	PHT03, PHT22, PHT32
8)	relative system responses of PHT bandpasses (not used by OLP, for computation of cc factors not covered by color correction tables)	all AOTs except PHT40

1.2 Photometric Accuracies of Staring Modes

Global calibration accuracies have been estimated from the investigation of the test cases and the comparison with published reference photometry. (for a dependence on flux, see Table 1.2 below). They can be applied, if not one of the caveats on photometry applies, cf. Sect. 2.
The terms **absolute accuracy**, **relative accuracy** and **reproducibility** have been defined in the following context:

- **absolute accuracy** is the accuracy achieved w.r.t. the reference photometry, if the filter measurement had a corresponding FCS transfer measurement in the same filter. Hence, the quality of the FCS calibration against celestial standards is directly verified. Note that no calibration accuracy of the reference photometry (models, IRAS) has been taken into account, as this is beyond the scope of this report. A typical order of the absolute accuracy of the reference photometry is 2 – 10%. Table 1.2 lists the achieved values per detector and flux range.

- **relative (filter-to-filter) accuracy** is the accuracy achieved w.r.t. the reference photometry, if the filter measurement was not performed in the filter in which the FCS calibration was done. Currently, assumptions about the constancy of the responsivity over the full flux range and for all filters, and, related to that relative filter-to-filter correction factors, apply. It has been proven that this is in general not correct, and it is considered that in future OLP versions corrections for non-linearities of the responsivity with the in-band power will be applied. Hence, the relative uncertainty can be much larger than the absolute one in multi-filter measurements with certain source SEDs. Table 1.2 lists the achieved values per detector and flux range. The number of suitable test cases performed in multi-filter mode is much smaller than the number of test cases in any of the absolute measurement modes (i.e. with an FCS measurement in the respective filter). The relative filter-to-filter accuracy could only be established for a minor subset with no test case for C200.

- absolute and relative accuracy are assumed to add to the total photometric uncertainty. In multi-filter measurements with one FCS measurement the absolute measurement uncertainty is subtracted from all measurements in non-FCS filters in order to derive the relative measurement accuracy.

- **reproducibility** is the relative consistency of measurements repeated several times with the same measurement set-up. It is a measure of the internal stability of the instrument and describes also the current limitations in signal processing. Table 1.3 lists the achieved values per detector both for a bright secondary standard and a faint source. These values were obtained from special calibration monitoring programs performed during ISO's Routine Phase [4].

In summary, the following calibration accuracies have been achieved per detector:

1) **ISOPHOT-P1:**
10 % absolute accuracy and 20 % relative accuracy for bright sources (> 30 Jy). For fainter sources the absolute accuracy is within 40%.
The relative reproducibility accuracy is 5 % for bright sources and 10 % for faint sources.

2) **ISOPHOT-P2:**
Better than 15 % absolute accuracy and 5 % relative accuracy.
The relative reproducibility accuracy is 2 % for bright sources and 12 % for faint sources.

3) **ISOPHOT-P3:**
Better than 15 % absolute accuracy and 10 % relative accuarcy down to $\sim$ 0.5 Jy. The relative reproducibility accuracy is 7 % for bright sources and 7 % for faint sources. Under extreme Space Weather conditions and for the very end of the science window the achieved accuracy for faint sources is poorer.

4) **ISOPHOT-C100:**
15 % absolute accuracy and 25 % relative accuracy down to $\sim$ 5 Jy. The absolute accuracy of nodding photometry in the flux range below 1 Jy is 40 %. The absolute accuracy in mini-map mode is $\sim$ 40 %.
The relative reproducibility accuracy is 3 % for bright sources and 20 % for faint sources.

5) **ISOPHOT-C200:**
10 % absolute accuracy for fluxes down to 0.5 Jy. At the lowest flux level only absolute photometry and nodding mode achieve this accuracy. The accuracy achieved in mini-map mode is $\sim$ 40% for the full flux range. Due to the signal linearity correction the multi-filter test case of α Boo indicates that a relative accuracy better than 30 % can be achieved down to fluxes of a few Jy, limited by the accuracy to subtract the then 4 times brighter background.
The relative reproducibility accuarcy is around 10% both for bright and faint sources.

6) **ISOPHOT-S:**
Due to a new spectral response function for chopped ISOPHOT-S measurements accuracies have been trimmed up to 10 % absolute and 10 % relative (for spectral shape).
For staring mode observations the standard spectral response function may not work accurately for some flux ranges due to signal transients and therefore the more conservative numbers of better than 30 % absolute and better than 30 % relative still apply. For extended source staring observations the same numbers apply, as the test cases indicate that an additional uncertainty introduced by the amount of the solid angle is now properly corrected for.

1.2.1 Photometric Accuracy Limitations

Aperture photometry of point sources on mini-maps is limited to $\sim$ 40 %. Investigations on possible reasons for this performance, like flat-field accuracy, background variations, array filling factors, size of map for background subtraction have to be investigated in greater depth.

Table 1.2: Absolute and relative (filter-to-filter) calibration accuracies per detector achieved for various flux ranges in multi-filter mode with OLP V8.4. For quoted PHT-S accuracies in staring mode refer to Ref. [5].

detector	**AOT mode**	**flux range** [Jy]	**abs. accuracy** [%]	**rel. accuracy** [%]	**standard**
P1	P03 off & on	300 - 6000	$\leq$ **5**	15	α Boo
P1	P03, P05 off & on	70 - 1250	10	25	γ Dra
P1	P03 off & on	50 - 1000	10	10	Sirius
P1	P05 off & on	50 - 1000	**5**	–	Sirius
P1	P03 off & on	30 - 300	**10**	**10**	Vega
P1	P03 nodding	2	$\leq$ **5**	–	HR 5986
P1	P03 nodding	< 0.1	40	–	HD 172323
P2	P03 off & on	100 - 200	$\leq$ 5	5	α Boo
P2	P03, P05 off & on	25 - 40	< 10	**5**	γ Dra
P2	P05 off & on	~ 20	$\leq$ **15**	–	Sirius
P2	P03 nodding	0.5	$\leq$ 10	–	HR 5986
P3	P03 off & on	10 - 25	10	**5**	α Boo
P3	P03 nodding	20	$\leq$ **5**	–	α Tau
P3	P03, P05 off & on	~ 5	10	**10**	γ Dra
P3	P03 nodding	1 - 2	**10**	–	HR 617
P3	P03 nodding	0.6	$\leq$ 15	–	HR 7310
C100	P22 off & on	6 - 25	5	10	α Boo
C100	P22, P25 off & on	~ 5	15	**25**	γ Dra
C100	P22 nodding	~ 3.5	15	–	Sirius
C100	P22 nodding	0.2 - 0.6	40	–	HR 7310
C200	P25 off & on	500 - 900	**10**	–	Uranus
C200	P25 off & on	40 - 120	**10**	–	Ceres
C200	P22 off & on	2 - 5	< **10**	< **30**	α Boo
C200	P22 nodding	~ 0.5	< **10**	–	γ Dra
C200	P25 off & on	~ 0.5	**10**	–	γ Dra
SS	P40 off & on	2 - 5000	< 30	< 30	
SS	P40 chopped		**10**	< **10**	
SL	P40 off & on	1 - 5000	< 30	< 30	
SL	P40 chopped		**10**	< **10**	

1.3 Re-validation of Staring Mode Photometry and Spectroscopy

1.3.1 Flux Dependent Signal Linearization

This general calibration feature was successfully implemented. A prerequisite for this was a consistent treatment of a significant fraction of the PHT calibration files which were provided for this OLP version. There are a few areas where fine-tuning is possible.

1.3.2 PSF factors for PHT-C arrays

The upgraded PSF factors for the PHT-C arrays provide consistent photometric results, in particular for all filters of C200.

Table 1.3: Relative Calibration Reproducibility Accuracy per Detector for Bright and Faint Fluxes from Monitoring Programs.

detector	target	**flux** [Jy]	**relative accuracy 1 σ** [%]
P1	NGC 6543	8	5
P1	HD 172323	0.085	10
P2	NGC 6543	100	2
P2	HR 5986	0.67	12
P3	NGC 6543	100	7
P3	HR 7310	0.67	7
C100	NGC 6543	50	3
C100	HR 7310	0.23	20
C200	NGC 6543	11	10
C200	HR 6705	0.67	7

1.3.3 Multi-filter Staring Modes

The PHT staring photometric modes PHT03 and PHT22 OLP processing was successfully re-validated. This includes extended source photometry with PHT-C (PHT22). In general both the absolute and relative calibration are improved by this OLP version, see Sect. 1.2 above.

1.3.4 Absolute Photometric Modes

The PHT absolute photometric modes PHT05 and PHT25 OLP processing was successfully re-validated. The absolute calibration of PHT-P is improved for this version, see Sect. 1.2 above.

1.3.5 Spectroscopy in Staring Mode on Extended Sources

The PHT OLP processing of the spectroscopic mode PHT40 staring on extended sources was successfully re-validated. Spectral shapes and features are maintained. Good matches in absolute level and relative shape with reference spectra and photometry are found.

1.3.6 Spectroscopy in Chopped Mode

The PHT OLP processing of the spectroscopic mode PHT40 OLP chopping was successfully re-validated. Resulting spectral shapes and final accuracies could be improved to an absolute accuracy of 10 % and a relative accuracy of $<$ 10 %.

1.4 Validation

1.4.1 Chopped Photometry

The full assessment of the performance of chopped photometric modes has to await version 2.0 of this report.

1.4.2 Mapping Modes

Point source photometry from PHT22 raster maps is as accurate as $\sim 40\,\%$, independent of the selected raster step size. The full validation of the PHT22 mapping mode has to await version 2.0 of this report when flat-field accuracies will have been determined and absolute photometric accuracies of sky background photometry will have been derived from comparison with COBE/DIRBE photometry for a wide range of surface brightness.

A preliminary overview per detector and flux range is presented in Table 1.4 for single pointing background measurements. Note that the accuracy of COBE annual maps for 140 and 240 μm is typically 20%. For weekly maps it can be even worse. For wavelengths less equal than 100 μm the quoted accuracy is in general $\leq 1\%$.

Table 1.4: Calibration Accuracy per Detector for Extended Sources for Various Flux Ranges with OLP V8.4

detector	**flux range** [MJy sr^{-1}]	**absolute accuracy** [%]	**relative accuracy** [%]	**standard**
C100	5 - 15	20	20	COBE/DIRBE
C200	4 - 10	20	20	COBE/DIRBE

1.5 Status of Scientific Validation of PHT AOTs

The current validation status per AOT submode is given in Table 1.5. Note that this is preliminary with regard to modes to be validated during OLP V8.4 validation. The final assessment with regard to chopped photometry and PHT22 raster maps will be provided with Version 2.0 of this report. The table also provides an overview of the next steps to further upgrade both validated and non-validated modes and for which OLP version improvements can be expected.
In Table 1.6 we list the validated modes per detector sub-system. For completeness we have added the polarisation modes which can only be evaluated interactively using PIA and special FORTRAN routines.

1.6 General Points

- This report provides useful input for the general instrument cross-calibration (PHT photometric results of calibration standards).
- This report demonstrates what can be done scientifically with PHT OLP Auto Analysis Results (AAR). All comparisons with models and reference photometry are based on AAR results, without any fine tuning of data with PIA, but background subtraction and color correction were done as extra steps.

1.7 Limitations and Caveats

Limitations and Caveats are summarized in the subsequent section.

Table 1.5: Scientific Validation of OLP AOT Processing, August 99. FCS aper: correction for use of non-standard apertures in FCS measurement; beam: determination of effective solid angle; chop: chopper signal correction, including correction of chopped FCS measurement; drift: correction of non-linear baseline drifts in maps; flat-field: improvement of flat-field correction using actual sky measurement; map cal: assessment of accuracy of photometry from maps; dyn rsrf: non-static spectral response function correcting for signal transient effects.

AOT	**submode**	**scientifically valid since**	**next upgrades**	**foreseen in OLP Vx.y**
PHT03	staring point source	V6		
			FCS aper	9.2
	staring extended source	no	beam	9.2
	nodding	V6		
			FCS aper	9.2
	chopped point source	TBD	chop	**8.4**
	raster map	no	map cal	9.2
			drift	10.0
PHT04	staring point source	no	beam & FCS aper	9.2
	staring extended source	no	beam	9.2
	chopped point source	no	chop	9.2
			beam	9.2
PHT05	staring point source	V6		
			FCS aper	9.2
	staring extended source	no		
			beam	9.2
PHT17/9	staring point source	V6		
			FCS aper	9.2
	staring extended source	no	beam	9.2
PHT22	staring point source	V7		
	staring extended source	V7		
	nodding	V7		9.2
	chopped point source	TBD	chop	**8.4**
	raster map	V8.4(TBC)	map cal	**8.4**
			flat-field	9.2
PHT25	staring point source	V7		
	staring extended source	V7		
PHT32	chopped mapping	no	chop & map cal	10.0
PHT37/9	staring point source	V7		
	staring extended source	V7		
PHT40	staring point source	V5	dyn rsrf	9.2
	staring extended source	V6	dyn rsrf	9.2
	chopped point source	V6		

Table 1.6: Scientifically Validated Observing Modes per Detector, August 99

detector	**scientifically validated mode**	**AOT**
P1	absolute photometry point sources	PHT05
	staring multi-filter photometry point sources	PHT03
	faint source multi-filter nodding	PHT03
	multi-filter sparse map	PHT17/18/19
P2	absolute photometry point sources	PHT05
	staring multi-filter photometry point sources	PHT03
	faint source multi-filter nodding	PHT03
	multi-filter sparse map	PHT17/18/19
	polarimetry (PIA)	PHT50
P3	absolute photometry point sources	PHT05
	staring multi-filter photometry point sources	PHT03
	faint source multi-filter nodding	PHT03
	multi-filter sparse map	PHT17/18/19
C100	absolute photometry point sources	PHT25
	absolute photometry extended sources	PHT25
	staring multi-filter photometry point sources	PHT22
	staring multi-filter extended sources	PHT22
	faint source multi-filter nodding	PHT22
	multi-filter sparse map	PHT37/38/39
C200	absolute photometry point sources	PHT25
	absolute photometry extended sources	PHT25
	staring multi-filter photometry point sources	PHT22
	staring multi-filter extended sources	PHT22
	faint source multi-filter nodding	PHT22
	multi-filter sparse map	PHT37/38/39
	polarimetry (PIA)	PHT51
SS/SL	staring point source spectroscopy	PHT40
	extended source spectroscopy	PHT40
	chopped point source spectroscopy	PHT40

Chapter 2

Known Limitations and Caveats

This section addresses the limitations and caveats of the PHT calibration file Version 5.4 and the OLP implementation 8.4 which have been identified during the scientific pipeline validation process. It addresses also which caveats from calibration file Version 4.0 and OLP version 7.0 have been closed out by this latest version.

2.1 Validity Ranges of FCS Calibration Files

OLP 7.0 contained the following caveats concerning the validity ranges of the FCS calibration files (cf. Report on the Scientific Validation for PHT OLP 7.0 [1]:

1 *OLP 7.0 Caveat:* A poorer calibration accuracy can be expected for observations for which the headers of the PHT data products indicate that the FCS power settings were outside the validity range given in the header of the P*FCSPOW*.FITS CAL-G files. The deviation is larger for extrapolations further away from the validity range.

2 *OLP 7.0 Caveat:* The FCS calibration for P3, C100 and C200 before revolution 94 is less well sampled with standard calibration observations, than after revolution 94. Therefore, the quality of the FCS calibration of observations before revolution 94 can be poorer as compared to observations taken later in the mission. This also applies for the FCS flat-field calibration for the C100 and C200 detectors.

For OLP 8.4 the FCS calibration files were derived once more, now based on the final complete data set of calibration measurements acquired during the mission. Furthermore, the generation of the calibration curves included the flux dependent signal linearization. Consequently revised limits resulted. Table 2.1 lists the limits used for OLP V7.0 and OLP V8.4.
The limits for the validity of the FCS ranges are included in the headers of the relevant FCS calibration files. Only a warning is written to the product file headers indicating the limit violation and possible degradation in calibration. To derive responsivities for the full range of electrical FCS powers used in the AOTs the lower and upper ends of the calibrated ranges were extrapolated using a model of the FCS (grey body).
Therefore, both OLP V7.0 caveats remain for OLP Version 8.4:

Caveat 1: A poorer calibration accuracy can be expected for observations for which the headers of the PHT data products indicate that the FCS power settings were outside the validity range given in the header of the P*FCSPOW*.FITS CAL-G files. The deviation is larger for extrapolations further away from the validity range.

Due to a change in the illumination characteristics of the long wavelength section of the FCS in the beginning of revolution 94, the FCS power files for the FIR detectors P3, C100, and C200 are time dependent. Before revolution 94 the coverage of the calibration curves by standard sources is less good than for the rest of the mission. This affects only a small number of routine observations (from rev. 79 to rev. 93):

Caveat 2: The FCS calibration for P3, C100 and C200 before revolution 94 is less well sampled with standard calibration observations, than after revolution 94. Therefore, the quality of the FCS calibration of observations before revolution 94 can be poorer as compared to observations taken later in the mission. This also applies for the FCS flat-field calibration for the C100 and C200 detectors.

Table 2.1 compares the valid ranges of the main FCS, FCS1, for OLP V7.0 and OLP V8.4 (in mW of electrical FCS power). In general the ranges remain more or less the same, except for filters P_11.3, C_60, C_90, C_100, C_105 and C_160 for which in the case of after revolution 94 measurements a considerable extension of the valid range could be achieved. Note that strictly speaking for PHT-P the power range is associated with the corresponding standard aperture (cf. Sect. 2.2 for a table of the standard apertures per PHT-P filter and additional caveat).

Table 2.1: Validity Ranges of FCS Tables (for FCS1 only)

	up to revolution 93				**after revolution 93**			
	OLP V7.0		**OLP V8.4**		**OLP V7.0**		**OLP V8.4**	
Filter	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**
P_3.29	17.48	50.00	17.48	50.00	17.48	50.00	17.48	50.00
P_3.6	11.29	50.01	9.49	50.01	11.29	50.01	9.49	50.01
P_4.85	13.30	35.34	15.01	35.34	13.30	35.34	15.01	35.34
P_7.3	7.48	22.13	7.48	22.13	7.48	22.13	7.48	22.13
P_7.7	8.59	24.41	8.59	24.41	8.59	24.41	8.59	24.41
P_10	4.47	11.49	5.45	11.49	4.47	11.49	5.45	11.49
P_11.3	4.81	8.92	4.81	11.78	4.81	8.92	4.81	11.78
P_11.5	3.50	9.49	3.73	9.68	3.50	9.49	3.73	9.68
P_12.8	4.00	7.63	3.65	7.63	4.00	7.63	3.65	7.63
P_16	2.66	6.58	2.66	6.58	2.66	6.58	2.66	6.58
P_20	1.72	4.00	1.72	4.00	1.72	4.00	1.72	4.00
P_25	1.40	3.61	1.40	3.61	1.40	3.61	1.40	3.61
P_60	1.34	2.98	1.05	2.98	0.42	2.13	0.42	2.13
P_100	0.42	1.84	0.42	1.84	0.27	1.84	0.27	1.84
C_50	1.93	4.23	1.03	4.23	0.59	4.36	0.59	5.27
C_60	1.23	3.88	1.09	3.88	0.77	3.05	0.39	6.39
C_70	0.75	4.03	0.74	4.03	0.43	3.15	0.43	3.15
C_90	0.54	1.93	0.46	1.93	0.29	1.94	0.29	4.40
C_100	0.46	2.03	0.46	2.03	0.20	1.75	0.20	3.79
C_105	0.40	2.22	0.40	2.22	0.20	3.09	0.20	5.84
C_120	0.31	1.86	0.31	1.86	0.24	3.47	0.24	3.47
C_135	0.27	1.34	0.27	1.34	0.17	2.66	0.17	2.60
C_160	0.22	1.16	0.22	1.16	0.13	1.62	0.07	2.45
C_180	0.27	1.90	0.27	1.90	0.18	2.91	0.12	2.88
C_200	0.22	0.81	0.22	0.81	0.13	5.78	0.16	5.78

2.2 Inhomogeneous FCS Illumination of PHT-P Apertures

The illumination of the both the PHT-P apertures and the PHT-C arrays by the internal Fine Calibration Source (FCS) is not flat. As a result the illumination of the detector does not scale with the area of the aperture. This effect is corrected for in the case of PHT-C by the so-called illumination matrix (PC1ILLUM and PC2ILLUM cal-G files). Currently, for PHT-P linearity with the aperture area is assumed and the corresponding PHT-P CAL-G files (PP1FCSAP, PP2FCSAP and PP3FCSAP) only contain correction factors of 1 (i.e. they do not imply any correction).

Table 2.2: ISOPHOT Standard Calibration Apertures

Filter	**Standard Aperture**
P_3.29	23”
P_3.6	23”
P_4.85	23”
P_7.3	23”
P_7.7	23”
P_10	52”
P_11.3	52”
P_11.5	52”
P_12.8	52”
P_16	52”
P_20	79”
P_25	79”
P_60	180”
P_100	180”

Therefore the following caveat remains in place:

Caveat 3: In case the FCS calibration of an observation is performed in a non-standard aperture of this filter (cf. Table 1) strong deviations (factor $\simeq 2$) of the correct responsivity and thus the derived fluxes can occur. The deviations are strongest for the usage of the largest apertures in combination with P1 filters.

2.3 Non-geometric Aperture Beam Size Scaling

By evaluation of multi-aperture measurements on flat backgrounds it has been found that in some filters strong non-linear behaviour w.r.t. the geometrical aperture area occurs (in particular for the largest apertures, $\geq$ 120”, of the 11.5 micron filter). This means, that, if observations are performed in apertures deviating strongly from the ones used in calibration (cf. Table 2.2), deviations from the correct flux can occur. This is especially of importance for multi-aperture measurements, because often background measurements are performed in different (larger) apertures than the related source observations and are scaled to the corresponding on-source aperture size.
The extended source calibration and the correction for non-geometric beam size effects had to be delayed to OLP 9.2. Currently, the s/w uses the geometrical beam sizes only. Therefore the following caveat still applies:

Caveat 4: If observations are performed in apertures, which are different in diameter from the ones used in standard calibration, deviations from the correct flux calibration can occur. This implies especially for extended source or background observations using the largest apertures with P1 and P2.

2.4 Non-linearity of Detector Responsivity with Flux

It has been a major calibration project for OLP V8.4 to characterize the non-linearity of the detector systems with incident flux. New calibration files PP1SLINR, PP2SLINR, PP3SLINR, PC1SLINR, PC2SLINR have been established which provide a linearization of the detector signals so that the responsivity becomes homogeneous for the full applicable flux range.

With the successful implementation of this correction, the OLP 7.0 caveat:

1 *OLP 7.0 Caveat* Measurements with inband powers far away ($\geq$ factor 10) from the ones used for the related FCS measurement(s) have poorer calibration accuracy.

is no longer applicable for OLP version 8.4. Note however, that the linearity calibration is only valid for certain signal ranges. Table 2.3 lists the lower and upper signal limits as given in the headers of the calibration files PP1SLINR, PP2SLINR, PP3SLINR, PC1SLINR, PC2SLINR. The polynomial approximations to the non-linearity curves are not extrapolated beyond the calibrated signal ranges but are kept at the level of the boundary. In different filters different relative signal ranges may be covered so that in some cases with signals at the boundaries of the calibrated ranges some unsteadiness may be introduced.

Table 2.3: Calibrated Signal Ranges of Non-linearity Correction Tables

Detector	**Filter**	**Lower Limit** [V/s]	**Upper Limit** [V/s]
P1	3.3	-0.000384888	55.385299683
P1	3.6	-0.000682076	166.108993530
P1	4.8	-0.000602098	126.773002625
P1	7.3	-0.000000214	95.497596741
P1	7.7	-0.000000075	27.142700195
P1	10.0	-0.000000075	23.474100113
P1	11.3	0.000000064	2.860069990
P1	12.0	0.021128900	35.688999176
P1	12.8	0.031093700	11.422900200
P1	15.0	0.019538499	3.659840107
P2	20.0	0.075110599	9.460639954
P2	25.0	0.099758998	10.925999641
P3	60.0	0.248281002	56.333801270
P3	100.0	0.266714007	68.093002319
C100	60.0	0.000000073	60.075801849
C100	65.0	0.000000089	48.521099091
C100	80.0	0.116841003	32.235000610
C100	90.0	0.000000026	47.538600922
C100	100.0	-0.000000059	38.957199097
C100	105.0	-0.000000444	35.681499481
C200	120.0	-0.000000422	32.326099396
C200	150.0	-0.000000159	35.590999603
C200	170.0	0.000000103	36.756500244
C200	180.0	0.000000316	22.571100235
C200	200.0	0.000000316	9.415360451

2.5 Detector Signal Transients

PHT OLP does not use physical (Fouks) or empirical (exponential, signal jump) signal transient correction functions, as they are available in the PIA, because those require still a highly interactive mode. Currently OLP detects detector transients by statistical trend analysis methods and discards parts of a measurement found to be affected by drifts. This method works reasonably well, if a given measurement reaches stability, i.e. for bright sources and for very long observations. The condition that stability is achieved is that the variation of the signals during the considered time interval is less than 5%. Then the signals within the stability period are used to derive the final signal per chopper plateau. In case this criterium is not met, OLP uses the weighted mean of the last 8 signals.

Caveat 5: The transient correction only works satisfactory for measurements longer than the detector transient time constant at a given illumination. The transients are very often the limiting factor for the achieved accuracy. Measurements flagged by the OLP software as *"plateau data affected by residual drift"* can show strong deviations (residual drift is greater than 5%) from the correct result.

Note: The quality of an observation, w.r.t. drift and other criteria is coded into the SPD field **PxxSFLAG** where xx identifies the detectors as follows: C1, C2, P1, P2, P3, SS and SL. The flags are given for each chopper plateau individually and are defined in the OLP include file SPP_PIX_FLAGS_PAR.INC. The following table gives an overview:

Table 2.4: Quality flags for PHT SPD Data

Flag	**Description**
0	normal
1	calibration measurement saturated
2	part of plateau data affected by drifts
3	all ramps on plateau rejected
4	plateau data affected by residual drift
5	zero standard deviation
7	zero signal for plateau

2.6 Long Term Detector Drifts

For single pointing measurements with one FCS measurement per detector no attempt is made by PHT OLP software to correct for long term detector responsivity drifts, i.e. stability of the detector responsivity during the execution time of an AOT is assumed. For raster pointing observations and sparse maps OLP does a linear interpolation with time of the responsivity values derived from the two bracketing FCS measurements. Detailed investigation of PHT-C maps has shown that the detector long term drift is not linear, but very often shows an exponential behaviour due to switch-on effects. Therefore, models of the detector behaviour or baseline fits would be required for optimum results.

Caveat 6: PHT OLP does not correct (in case of single pointings) or correct only with a linear interpolation (in case of maps) for long term detector drifts within an AOT.

2.7 Error Calculation and Propagation

Uncertainties provided by OLP 8.4 are still pure statistical errors from signal evaluation, as for OLP V7.0. In order to assess all other uncertainties it is necessary to refer to the related documentation on PHT calibration in combination with the OLP products. (cf. documents ISO Data User Manual (IDUM) [2] and ISOPHOT Error Budgets [3]).

Caveat 7: The PHT OLP software does only provide an uncertainty from the statistical signal evaluation. It does not give any estimates of the systematic uncertainties of all performed calibration steps. Therefore, OLP 8.4 uncertainties are **minimal** errors. It is essential to refer to special documentation which provide an overview of the uncertainties introduced step by step. These depend on the exact observing conditions and evaluation steps which may even not be completed inside OLP (e.g. background subtraction in maps or from independent staring measurements).

2.8 Missing Measurements and Chopper Correction

The current version of OLP does not perform a consistency check whether the number of measurements which were actually performed does match the number of measurements expected from the EOHA beyond an initial check during DERIVE_SPD. In case there are measurements missing in an AOT it is possible that there is a mismacth between the keywords written into the SPD header concerning the chopper correction parameters, w.r.t. the measurement number and the filter number that was actually used in a measurement.

Caveat 8: In case there are measurements missing from an AOT there may be a mismatch between the chopper correction keywords and the related filter number.

2.9 Limitations in Use of PHT Color Correction Factors

With the OLP V7.0 and CAL-G V4.0 for the first time CAL-G files with color correction factors for several different SEDs are provided. These color correction factors are not applied by PHT OLP, but can be applied inside PIA. They have been calculated from the bandpass transmission files currently available, which have typically about 300 data points equally spaced in wavelength. Two different interpolation and integration methods have been used to derive the color correction factors and they give equal results except for the cases where steep Wien branches are convolved with the bandpass transmission numbers. Furthermore, the bandpass transmission files used are centred on the main throughput range. All wavelengths for which the transmission was below 10^{-4} have been excluded. Taking into account the latest available data sets of all transmission components (filter transmission, field less transmission, blocking material transmission, spectral detector responses) the bandpass transmission of some filters (in particular P1 filters) need some update and refinement, because they show minor credible transmission peaks outside the main range. In case of extreme source SEDs these "leaks" can make a significant contribution to the resulting inband power and hence alter the corresponding color correction factor considerably.
Therefore, the following caveats have to be put onto the CAL-G V4.0 color correction factors:

Caveat 9: For the establishment of the color correction factors provided by CAL-G Version 4.0 not yet final PHT filter bandpass data including a wide wavelength range outside the nominal bandpass have been used. For some filters and in the case of extremely rising or falling SEDs this can mean an underestimate by out-of-band contributions. Color correction factors above 2 should be considered as less accurate and factors above 4 only as an indication of the order of the correction, as they clearly depend on the integration and interpolation method used. This applies in particular for SEDs of cold sources in combination with the P1 filters which fall onto the steep Wien branch of these SEDs. In these cases it is recommended to contact the ISO Data Centres for the most recent bandpass transmission and establish the color correction factor yourself.

2.10 Empirical PPSF Correction Factors for Array Centered C200 Photometry

For OLP 7.0 the following caveat had been imposed on the data products:

1 *OLP 7.0 Caveat:* The correction factors for the filters C_180 and C_200 appear to be too large by 20 to 30%. Photometric fluxes derived for both filters in array centered mode should be corrected towards larger values by this percentage (as the uncorrected flux value is divided by the PPSF factor).

For OLP 8.4 the empirical factors have been redetermined from a larger calibration data set. For comparison we list theoretical and the empirical ones for OLP V7.0 and OLP V8.4 in Table 2.5:
The new values are smaller than the old ones for all filters and confirm two findings:

1 the strong deviation from the theoretical values for the shorter wavelengths.

Table 2.5: PPSF Factors for Array Centered C200 Photometry

C200 Filter	**theoretical PPSF**	**empirical PPSF OLP V7.0**	**empirical PPSF OLP V8.4**
C_120	0.814	0.574	0.498
C_135	0.846	0.668	0.568
C_160	0.733	0.708	0.528
C_180	0.818	0.972	0.612
C_200	0.655	1.054	0.693

2 the strong correction for the C_180 and C_200 values with regard to the OLP V7.0 values in the direction as predicted by the OLP V7.0 caveat.

Scientific validation of the OLP 8.4 products has demonstrated that this caveat is no longer applicable.

2.11 Incomplete Raster Map Appearance in Case of Zero Signal Flag

A new caveat from OLP 8.4 Scientific Validation comes from the investigation of PHT-P raster maps:

Caveat 10: In case the total flux on the detector is very small resulting in close to zero or even negative signals at the end of the DERIVE_SPD processing stage OLP, sets the "zero signal flag" for the corresponding plateaux times and does not continue to process these data sections in DERIVE_AAR (cf. description of SPD product types, coding of pixel status flag PPxSFLAG; a listing of the quality flags is given in Table 2.4). This leads then to incomplete appearing map products PGAI. The most likely cases are the short wavelength filters of PHT-P1, where the sky background (Zodiacal Light) shows a minimum, in combination with small aperture sizes.

Bibliography

[1] U. Klaas and M. Radovich, "Report on the PHT Scientific Validation for OLP Version 7.0", SAI/98-049/Rp, Version 2.0, 20-July-1998.

[2] R.J. Laureijs, U. Klaas, P.J. Richards and B. Schulz, "ISO Data User Manual (IDUM)", SAI/95-220/Dc, Version 4.0, October 1998

[3] R.J. Laureijs and U. Klaas, "ISOPHOT Error Budgets", SAI/98-091/Dc, Version 1.0, 21-April-1999 (DERIVE_SPD Processing Steps)

[4] B. Schulz & S. Huth, "Explanatory Supplement for FCS Monitoring Observations", Draft 2.0, 20-June-97 and related diagrams

[5] U. Klaas, J.A. Acosta–Pulido, P. Ábrahám, H.O. Castañeda, L. Cornwall, F. Garzon, P. Hammersley, I. Heinrichsen, U. Kinkel, D. Lemke, J. Schubert, and M. Wells, "ISOPHOT-S: Capabilities and Calibration", Proc. First ISO Workshop on Analytical Spectroscopy, p. 113, ESA SP-419, December 1997