Release Note for ISOPHOT OLP Version 8.4 [1]

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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.

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.

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 (incl. re-normalization of default responsivities)	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

- 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 (cf. Tables 1.2 and 1.3 for details):

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:
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. Thanks to a new calibration method with spectral response functions specific for chopped mode and adjusted to the detector behaviour for a certain flux modulation, 10 % absolute accuracy and 10 % relative accuracy are achieved for chopped point source observations, in the flux range 0.5 to about 500 Jy with the SS detector, and in the flux range 0.2 to about 200 Jy with the SL detector.

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. Bold values indicate a significant improvement w.r.t. OLP V7.0. 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	$\sim$ 25	$\leq$ **15**	–	Sirius
P2	P03 off & on	$\sim$ 25	20	–	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	$\sim$ 5	10	**10**	γ Dra
P3	P03 nodding	1 - 2	**10**	–	HR 617
P3	P03 nodding	0.6	$\leq$ 15	–	HR 7310
P3	P17/18/19 4 times	< 0.2	**20**	–	HR 5981
C100	P22 off & on	6 - 25	5	10	α Boo
C100	P22, P25 off & on	$\sim$ 5	15	**25**	γ Dra
C100	P22 nodding	$\sim$ 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	$\sim$ 0.5	< **10**	–	γ Dra
C200	P25 off & on	$\sim$ 0.5	**10**	–	γ Dra
SS	P40 off & on	2 - 5000	< 30	< 30	
SL	P40 off & on	1 - 5000	< 30	< 30	

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 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. This implementation removes an OLP V7.0 caveat (cf. Sect. 2.4). 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. This calibration upgrade removes an OLP V7.0 caveat (cf. Sect. 2.10).

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

In summary, the following calibration accuracies have been achieved per detector and flux range (cf. Table 1.4 for details):

1) ISOPHOT-P1:
Better than 10 % absolute in the flux range 1 - 10 Jy, better than 50 % absolute down to fluxes of 50 mJy.

2) ISOPHOT-P2:
Better than 40 % absolute in the flux range 0.2 - 6 Jy, albeit it appears that in the flux range 0.5 - 3.5 accuracies in the order of 10 % absolute can be achieved. So far no signal correction is applied to P2 data. This seems, however to be necessary, as general trends can be observed from the test data and signal correction factors should be established for the next OLP version.

3) ISOPHOT-P3:
Better than 40 % absolute in the flux range 1.5 - 20 Jy, with better than 20 % above a flux of 5 Jy.
Relative accuracies are in the order of 20 - 30 %.

4) ISOPHOT-C100:
Better than 60 % absolute in the flux range 0.2 - 15 Jy. Below 0.2 Jy fluxes become less and less reliable, presumably due to an insufficient chopper offset correction which leads to factors 2 - 4 too high fluxes in the flux range 0.03 - 0.15 Jy.
Relative accuracies are in the order of 50 %

5) ISOPHOT-C200:
Better than 20 % absolute in the flux range 2 - 5 Jy. Below 1 Jy, in general negative flux values are derived, presumably due to an insufficient chopper offset correction or due to a non-detection because of sky noise (cirrus confusion).
Relative accuracies are in the order of 20 %.

Based on the results per detector listed above, chopped photometry with ISOPHOT-P and -C can not be declared as scientifically valid because of the too severe restrictions and caveats. These are:

1) In general the accuracy is not better than 40 - 50 %.

2) For C100 and C200 these accuracy values are limited to fluxes above 0.2 Jy and 1 Jy, respectively. For smaller fluxes the current chopper offset correction, being the zero point of the signal correction, is not yet sufficient.

3) For P2 very often an underestimation of the expected flux value is observed. A better accuracy should be achievable by establishment of signal correction factors which are currently not yet available.

Nevertheless the processing of chopped photometry has been significantly improved and for some detectors and flux ranges already reasonable accuracies have been achieved as listed above. It should also be noted that the SPD product contains now the so-called "chop pattern" which is a robust representation of the signal modulation for this measurement. In case of faint sources the interpretation of this chop pattern is not always straight forward for non-experts due to superimposed instrumental effects.

Table 1.4: Absolute and relative (filter-to-filter) calibration accuracies per detector for chopped photometry achieved for various flux ranges in multi-filter mode with OLP V8.4.

detector	**AOT**	**flux range** [Jy]	**abs. accuracy** [%]	**rel. accuracy** [%]	**standard**
P1	P03	2.5 - 10	**5**	–	HR 6817
P1	P03	1 - 2.6	**5**	**40**	BS 5062
P1	P03	2.2	**10**	–	HR 5986
P1	P03	0.06	$<$ **50**	–	HD 172323
P2	P03	25	$<$ **20**	–	Sirius
P2	P03	3.5 - 6	$<$ **40**	–	HR 6132
P2	P03	5	$<$ **40**	–	HR 7557
P2	P03	3.5	**10**	–	HR 7310
P2	P03	0.5	**10**	–	HR 5986,HD 185144
P2	P03	0.2 - 0.5	$<$ **40**	–	BS 5062,HR 5447 HR 5914,HR 4983 HD 185395
P3	P03	7 - 19	**20**	–	HR 1457
P3	P03	6 - 7	**15**	**20**	HR 7001
P3	P03	1.5 - 4.5	$<$ **40**	**30**	BS 6056
P3	P03	0.6	$<$ **40**	–	HR 7310
P3	P03	0.15	$<$ **60**	–	HR 5981
C100	P22	4 - 12	**20**	**60**	HR 8775
C100	P22	1.5 - 2	$<$ **60**	**30**	HR 6705
C100	P22	0.15 - 1.1	**10**	**10**	HR 7310,HD 203280 HD 12311,HD 187642
C100	P22	0.07 - 0.15	$<$ **20**	–	HR 5981, SAO248381 HD 142373
C100	P22	0.03 - 0.15	$>$ **+60**[a]	–	HR 5986,HR 7180 BS 5062,HR 5304 HD 142373
C200	P22	2 - 5	**15**	**20**	HR 5340
C200	P22	0.6	–[a]	–	HR 6705
C200	P22	0.02 - 0.15	–[b]	–	HR 7180,HR 7557
SS	P40	0.1 - 20	**10**	$<$ **10**	
SL	P40	0.1 - 10	**10**	$<$ **10**	

[a] insufficient chopper offset correction (frequency and pixel dependent)

[b] due to sky noise below detection limit for applied measurement time (best theoretical $1\,\sigma$ value: 64 mJy)

1.4.2 PHT22 Mapping Mode

The PHT22 raster mode is scientifically valid with some caveat on the achieved flat field accuracy in case of no pixel overlap (see summary below and caveat in Section 2.14). This validation is based on the following findings with regard to flux conservation for different raster step sizes, flatfield accuracy, absolute surface brightness accuracy and point source photometry accuracy from maps:

- The flat-field accuracy for C100 maps depends on the pixel overlap, a summary is given in Table 1.6. In general ± 20 % (standard deviation of the mean background surface brightness) are achieved; for proper pixel overlap (shift by half of the array, i.e 1.5 pixels or less) the flat-field accuracy is 4 to 12 %. In case of no oversampling the flat-field accuracy is clearly limited by instrumental flat-field residuals producing systematic patterns, which need however not to be constant over the whole map area. These patterns are neither wavelength independent nor are they reproduced for the same filter. This points to non-linear drift effects and possibly sometimes temporary spiking of the individual pixels which cannot be corrected for by a linear interpolation between the two bracketing FCS measurements. In case of pixel overlap these flat-field residuals are averaged out.

- The flat-field accuracy for C200 maps depends on the pixel overlap and slightly on the absolute sky brightness, a summary is given in Table 1.6. In general $\pm$ 15 % (standard deviation of the mean background surface brightness) are achieved; for proper pixel overlap (shift by one pixel or fraction of one pixel) the flat-field accuracy is 3 to 5 %. In case of no oversampling the flat-field accuracy is clearly limited by instrumental flat-field residuals producing systematic patterns. These patterns are wavelength dependent. In case of pixel overlap by the selected raster step sizes these flat-field residuals are averaged out.
- Flat-field accuracies above 10 %, mainly found for maps with no pixel overlap and low surface brightness levels, and temporal variation of the flat-field residuals, found for C100 maps, mean a restriction of detecting faint sources and a caveat with regard to point source photometry performed on these maps.
- For C100 and C200 filters the consistency of the absolute surface brightness in ISOPHOT maps with COBE/DIRBE photometry is in general $<$ 25 % (for details, see Table 1.5). It should be noted that due to very different beam sizes considerable discrepancies between ISOPHOT photometry and COBE/DIRBE photometry is natural in areas with high dynamic flux range. The comparison is also limited by not yet applying color corrections for the different band pass transmissions and central wavelengths. Note also 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 %.
- Point source photometry from PHT22 raster maps is as accurate as $\sim$ 40 %, independent of the selected raster step size, see Table 1.7.
- The consistency of point source photometry of the same source observed in PHT22 raster mode with different raster parameters is $\pm$ 15 %, see Table 1.8. The consistency is very likely limited by the achieved flat-field accuracy (see below). We conclude that the OLP gridding algorithm for maps conserves the flux.

Table 1.5: Calibration Accuracy per Detector for Extended Sources for Various Flux Ranges with OLP V8.4. The range for which both absolute and relative accuracies can be given is covered by multi-filter background measurements, while the larger range is covered by raster maps.

detector	**flux range** [MJy sr^{-1}]	**absolute accuracy** [%]	**relative accuracy** [%]	**standard**
C100	5 - 15	$<$ 25	20	COBE/DIRBE
	5 - 400	$<$ 25	–	COBE/DIRBE
C200	4 - 10	$<$ 25	20	COBE/DIRBE
	3 - 600	$<$ 25	–	COBE/DIRBE

Table 1.6: Flat-field (ff) accuracies for ISOPHOT-C P22 raster maps. The ff accuracies are determined as ratio of the standard deviation of the mean background surface brightness to the mean surface brightness value for a flat sky background field with no sources. They are filter independent. There is some trend that for the same set of raster parameters the ff accuracy improves with increasing absolute surface brightness. For C100 the ff accuracy can vary over the map area.

detector	**flat-field accuracy** no pixel overlap (%)	**flat-field accuracy** with pixel overlap (%)
C100	8 - 20	4 - 12
C200	7 - 15	3 - 5

Table 1.7: Absolute calibration accuracies achieved for various flux ranges in mini-map mode.

detector	**flux range** [Jy]	**abs. accuracy** [%]	**standard**
C100	1 – 5	30	Sirius
C200	500 – 900	30	Uranus
C200	40 – 120	30	Ceres
C200	0.6	50	γ Dra
C200	0.4	30	HR 1654

Table 1.8: Results from comparison of sets of P22 raster maps with different raster step size. Internal consistency is derived as the ratio of half of the difference in flux to the average flux for a pair of maps on the same target.

target name	**filter** (μm)	**raster parameters** MxN	**raster parameters** dMxdN (arcsec)	**flux** (Jy)	**internal consistency** (%)
C100 detector					
BD+31 643	60	11 x 11	69 x 69	325.757	+1.0
BD+31 643	60	9 x 9	15 x 15	319.498	-1.0
HR 1457	100	9 x 3	69 x 69	5.464	-13.6
HR 1457	100	7 x 7	15 x 15	7.189	+13.6
C200 detector					
HR 2020	170	2 x 2	90 x 90	2.389	-14.3
HR 2020	170	3 x 3	46 x 46	3.187	+14.3
NGC 6543	170	4 x 4	92 x 92	20.884	-16.0
NGC 6543	170	10 x 10	46 x 46	28.817	+16.0
NGC 6503	170	4 x 4	92 x 92	42.828	-5.6
NGC 6503	170	10 x 10	46 x 46	47.932	+5.6
IC 1228	170	4 x 4	92 x 92	8.421	-25.7
IC 1228	170	10 x 10	46 x 46	14.236	+25.7

1.5 General Accuracy Limitations of OLP Processing

The previous sections provided an overview of the currently achievable average calibration accuracy using OLP products and Sect. 2 lists the conditions of limitations due to yet incomplete corrections or calibrations.
There are, however, a few general accuracy limitations which should be taken into account when using ISOPHOT data products:

- **Accuracy Limitations of Celestial Standards**
  During the course of the ISO project considerable improvements for certain classes of standard sources have been achieved by new observational programmes and refined modelling. One specific case from which ISOPHOT calibration benefited a lot were the new thermophysical models of asteroids [8]. On the other hand, it has to be noted that in the FIR range the stellar spectra a very often extrapolations of measured SEDs up to at most $35\,\mu$m. In particular for faint standard stars ($< 1\,$Jy) not much is known about the true SED in the FIR. There are indications that some standard stars do not have good flux predictions. Those will have to be identified by cross-calibration with other stars.

- **Measurement beyond Sensitivity Limit**
  There are measurements in the data base which did not apply the most optimal observing strategy (cf. [6], [7]). Then even the best reduction does not achieve a satisfying result. Sensitivity limits and the corresponding minimum exposure times are given in the above cited reference documents, which have been derived from actual ISOPHOT observations.

- **Confusion by Sky Background Structure**
  In the FIR the sky shows a significant structure, mainly due to IR cirrus (see [9] for a discussion on actual data). This sky confusion limits the ability to adequately determine a sky background and to derive accurate fluxes of faint sources. It can be partly circumvented by an optimized observing strategy (cf. [6], [7]) and by determining the sky background as close as possible to the source.

- **Processing Items which Require User Interaction**
  There are several processing steps from the raw data to the final data products for which interactive processing can provide much better results due to visual inspection of the intermediate data products and optimizing the processing parameters or due to interactive input by the user with regard to special properties of the source (extension, structure, etc.).

1.6 Areas of Improved Processing by Interactive Data Analysis

The provision of a percentage number characterizing which improvements in calibration accuracy can be obtained by careful interactive processing is currently not possible, since so far no comprehensive systematic investigation was performed. Interactive Analysis uses the same set of general calibration files (cal-G) as OLP. The limitations due to photometric bias, e.g. the accuracy of the standard source fluxes, fully apply to interactive calibration, too. One can expect, however, to achieve a higher accuracy with IA for the following cases (cf. [10] for a tutorial):

1) measurements with signal transients which do not stabilise during the measurement time, but which are long enough to perform a reasonable transient fit.

   a) PIA provides already the dynamic spectral response calibration for ISOPHOT-S.

   b) PIA provides several transient correction tools. The most efficient ones are the ones for ISOPHOT-S based on the Fouks-Schubert model (full drift modelling and initial signal jump) and the empirical solution for FIR detectors (P3, C100, and C200) based on exponential functions.

   c) PIA allows to view the transient fitting and to accept or reject it.

2) flat-fielding of maps, depending on the sampling mode and the dynamic range.

   a) In case of pixel overlap the redundancy information in the individual "pixel" maps can be used to do a flat-field correction using the sky measurement itself.

   b) For maps with large areas of flat sky background systematic flat-field residuals can be removed to a certain degree by determining the average and the relative flat-field residual pattern, even for maps with no pixel overlap. The average surface brightness is quite consistent with COBE/DIRBE photometry (cf. Table 1.5).

   c) In case of a sufficient dynamic range in surface brightness a statistical flat-field method can be applied establishing the correlations of the surface brightness per pixel with regard to a reference pixel. This method allows also to correct for additive offsets among the pixels.

3) correction of non-linear signal drifts in maps.

   a) The time sequence of the signals can be interactively inspected and non-linear baseline fits be applied in order to flatten the map.

4) detection of faint sources by refined deglitching and filtering.

   a) PIA offers more refined deglitching methods, like the two-threshold algorithm.

   b) Individual ramps or signal sequences can be inspected by eye and can be deselected or corrected manually.

5) photometry from mini-maps.

   a) The areas for determination of the sky background can be visually checked and selected.

   b) Knowledge of the beam footprint of a point source allows to correct for contamination of the background position by the source beam and to measure closely to the source in order to minimize cirrus confusion.

1.7 Status of Scientific Validation of PHT AOTs

With the finalisation of the OLP8.4 validation the current validation status per AOT submode is given in Table 1.9. With V8.4 the PHT22 raster mode has been scientifically validated. 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. There is, however, no warranty for a final implementation of a certain calibration feature, since this needs as a prerequisite a feasibility study including the establishment of the calibration algorithms and parameters.
In Table 1.10 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.

Table 1.9: Scientific Validation of OLP AOT Processing, January 2000. non-lin R: refinement of flux dependent signal linearization; 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	non-lin R	9.0
			FCS aper	10.0
	staring extended source	no	non-lin R	9.0
			beam	10.0
	nodding	V6	non-lin R	9.0
			FCS aper	10.0
	chopped point source	no	chop & non-lin R	9.0
	raster map	no	map cal	10.0
			drift	10.0
PHT04	staring point source	no	non-lin R	9.0
			beam & FCS aper	10.0
	staring extended source	no	non-lin R	9.0
			beam	10.0
	chopped point source	no	chop & non-lin R	9.0
			beam	10.0
PHT05	staring point source	V6	non-lin R	9.0
			FCS aper	10.0
	staring extended source	no	non-lin R	9.0
			beam	10.0
PHT17/9	staring point source	V6	non-lin R	9.0
			FCS aper	10.0
	staring extended source	no	non-lin R	9.0
			beam	10.0
PHT22	staring point source	V7	non-lin R	9.0
	staring extended source	V7	non-lin R	9.0
	nodding	V7	non-lin R	9.0
	chopped point source	no	chop & non-lin R	9.0
	raster map	**V8.4**	flat-field	10.0
PHT25	staring point source	V7	non-lin R	9.0
	staring extended source	V7	non-lin R	9.0
PHT32	chopped mapping	no	chop & map cal	10.0
PHT37/9	staring point source	V7	non-lin R	9.0
	staring extended source	V7	non-lin R	9.0
PHT40	staring point source	V5	dyn rsrf	9.0
	staring extended source	V6	dyn rsrf	9.0
	chopped point source	V6		
	raster map	V6	TBD	

Table 1.10: Scientifically Validated Observing Modes per Detector, January 2000

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
	staring multi-filter raster maps	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
	staring multi-filter raster maps	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). The validity range is given by the calibrated electrical heating power range (in mW) for each filter.

	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 of ISOPHOT-P is not yet finalized. 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	0.000	55.4
P1	3.6	0.000	166.1
P1	4.8	0.000	126.8
P1	7.3	0.000	95.5
P1	7.7	0.000	27.1
P1	10.0	0.000	23.5
P1	11.3	0.000	2.9
P1	12.0	0.021	35.7
P1	12.8	0.031	11.4
P1	15.0	0.019	3.7
P2	20.0	0.075	9.5
P2	25.0	0.100	10.9
P3	60.0	0.248	56.3
P3	100.0	0.267	68.1
C100	60.0	0.000	60.1
C100	65.0	0.000	48.5
C100	80.0	0.117	32.2
C100	90.0	0.000	47.5
C100	100.0	0.000	39.0
C100	105.0	0.000	35.7
C200	120.0	0.000	32.3
C200	150.0	0.000	35.6
C200	170.0	0.000	36.8
C200	180.0	0.000	22.6
C200	200.0	0.000	9.4

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

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

1 *OLP 7.0 Caveat:* In case there are measurements missing from an AOT there may be a mismatch between the chopper correction keywords and the related filter number.

With the revision of the chopped signal correction in OLP 8.4 the reading of the chopper corrections from the SPD header has been removed. Consequently, the caveat is no longer applicable.

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 were 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 lens 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.
For CALG V5.4 there was no re-determination of color correction factors. Therefore, the following caveats still apply for CAL-G V5.4 color correction factors:

Caveat 8: For the establishment of the color correction factors provided by CAL-G Version 5.4 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.

With CAL-G V5.4 the relative spectral system responses of all ISOPHOT-P and -C bandpasses are provided in the two new CAL-G files PPFILTRAN.FITS and PCFILTRAN.FITS. This enables observers to calculate color correction factors for any SED shape not covered by the dedicated color correction CAL-G files.

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:

Table 2.5: PPSF Factors for Array Centered C200 Photometry. Factors apply to the whole array, i.e. the sum of all 4 pixels.

C200 Filter	**theoretical PPSF**	**empirical PPSF OLP V7.0**	**empirical PPSF OLP V8.4**
C_120	0.814	0.574	0.498 ± 0.028
C_135	0.846	0.668	0.568 ± 0.029
C_160	0.733	0.708	0.528 ± 0.021
C_180	0.818	0.972	0.612 ± 0.046
C_200	0.655	1.054	0.693 ± 0.020

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.

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 9:** 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 for the short wavelength filters of PHT-P1, where the sky background (Zodiacal Light) shows a minimum, in particular in combination with small aperture sizes.

2.12 Application of Point Spread Function Fraction Factors to AAR Data Products

It should be noted that:

> **Caveat 10:** The point spread function fraction correction factors are applied to all data products associated to point source photometry, like PPAP and PCAP, regardless whether a background subtraction was performed or not. For staring mode observations without background subtration this has to be accounted for when subtracting the separate background measurement.

The background measurement can be either a point source photometry (in Jy), of type PPAP or PCAP, too:

$F_{src+back} = F_{on} / f_{psf}$
$F_{back} = F_{off} / f_{psf}$
$\rightarrow F_{src} = F_{src+back} - F_{back} = (F_{on} - F_{off}) / f_{psf}$

or an extended source measurement of type PPAE or PCAE (in MJy sr^{-1}; for the conversion of in-band power to surface brightness, cf. chapter 8.4.10 in [2]):

$F_{src+back} = F_{on} / f_{psf}$
$B_{back} = (F_{off\_pix} / ((1\text{-}\varepsilon^2) \cdot \Omega)$
$\rightarrow F_{src} = F_{src+back} - F_{back} = (F_{on} - n_{pix} \cdot (B_{back} \cdot (1\text{-}\varepsilon^2) \cdot \Omega)) / f_{psf}$

F_{on}, F_{off}, F_{off_pix} are fluxes in the aperture uncorrected for point source function effects (the latter one for one single pixel of the array). B_{back} is the surface brightness of the background.

Please note the following definitions with regard to application of f_{psf}-factors to header keywords :

1) For PPAP and PPAE:
   $f_{psf} = f_{psf}^{aperture}$
   $n_{pix} = 1$

2) For PCAP and PCAE staring modes:
   total flux of the array is used!
   $f_{psf} = f_{psf}^{array}$
   converted flux from surface brightness has to be multiplied with number of pixels, because the solid angle Ω is defined per pixel!
   $n_{pix} = 9$ for C100, $n_{pix} = 4$ for C200

3) For C100 PCAP and PCAE chopped mode (PHT22):
   $f_{psf} = f_{psf}^{pixel}$
   because only the central pixel is used!
   $n_{pix} = 1$
   Note that f_{psf}^{array} is applied to the data fields PCAPSRCE for consistency with the staring mode!

4) For C200 PCAP and PCAE chopped mode (PHT22):
   $f_{psf} = f_{psf}^{array}$
   $n_{pix} = 4$

2.13 Failure of Chopped Signal Pattern Generator in Case of Data Reduction

With OLP 8.4 a signal pattern of the chopped measurement is generated for a more robust determination of the difference signal. This pattern consists of 4 points each for the on-source and the off-source cycle, regardless of how many ramps per chopper plateau are actually performed (however, the minimum number of ramps is four per chopper plateau).

Caveat 11: In case of the data reduction factor being greater than 1 (i.e. for bright sources with very fast read-outs) the generation of the chopped signal pattern fails due to a timing jitter. The pattern will be zero and the resulting flux will be zero, too.

73 chopped photometry TDTs with a total of 113 measurements having a data reduction factor of at least 2 are affected. Solutions will be worked out for future OLP versions. In case a zero flux value is encountered for a chopped measurement, the pattern keyword PDlPmLn (l = filter number, m = pixel number, l = logical ramp number) in the SPD product should be checked for zero values.

2.14 Residual Flat-field Structures in PHT22 Raster Maps

As part of the scientific validation of PHT22 raster maps for OLP V8.4 the flat-field accuracies for maps having a wide range of selected raster parameters, with and without pixel overlap, and a wide range of sky background brightness have been assessed. It is found that in case of no pixel overlap flat field accuracies both for C100 and C200 are in general worse than 8 % (standard deviation of the mean sky bakground versus mean sky background). This limit is due to systematic flat-field residuals of the arrays and can be recognized as systematically repeated patterns in most of the maps. In addition, for C100 maps, temporal variations of these flat-field structures are found. This is linked to non-linear detector drifts as flagged in Sect. 2.6. Therefore, for OLP 8.4 the following caveat is imposed on mapping products PGAI:

Caveat 12: Systematic flat-field residuals in maps with no pixel overlap which account to between 10 and 20 % as well as temporal variations of the flat-field in case of C100 maps limit the ability of faint source detections and photometry on low sky background levels.

Chapter 3

Conclusions and Outlook

The Scientific Validation of the OLP 8.4 version has demonstrated and achieved the following:

- Further consolidation with improved photometric accuracy for staring mode observations, including faint source photometry.
- More detailed assessment of the photometric accuracy of absolute and multi-filter staring modes.
- Correction for non-linearity of signals due to flux dependence of detector responsivity.
- Upgraded FCS power tables from the full data set of celestial standard measurements obtained during the mission.
- Improvement of the effective solid angle of ISOPHOT-S.
- Improvement of the spectral response function for chopped PHT-S measurements resulting in considerably better absolute and relative accuracy.
- Validation of the staring PHT-C mapping mode PHT22.

The validation of chopped photometry calibration was not yet successful over a sufficiently large flux range for all ISOPHOT-P and -C detectors. However, the signal processing could be considerably improved by introducing the chopped pattern, a concept on which further improvements of the photometric calibration will built up. First refinements will be implemented for OLP 9.0, the final calibration method can, however, be only expected for OLP 10.0 (to be released in February 2001).

For the next PHT specific OLP Version 9.0, to be validated during spring 2000, the following items are confirmed for inclusion:

- Dynamic response correction for staring PHT-S measurements.
- Refinements for and validation of chopped photometry.
- Refinements in signal linearization and FCS calibration.
- Extension of data records in order to provide complementary flux information (Jy/pixel in case of extended source data product, MJy sr^{-1} in case of point source data product).

A basic schedule is outlined in the following Table 3.1.

Beside the consolidated items listed above the following items are still being considered for implementation into OLP:

- **Deglitching**
  Inclusion of the two-threshold algorithm to cope with glitch tails is being studied.

Table 3.1: Schedule for PHT OLP 9.0 Upgrades

OLP 9.0 requirements definition meeting	29-Nov-1999
Freeze of OLP 9.0 requirements	07/15-Jan-2000
Software and Cal-G file implementation (SPR fixing and new features)	Nov-1999 - Feb-2000
OLP 9.0 test plan	11-Feb-2000
OLP 9.0 software and calibration file delivery (1)	15-Feb-2000
OLP 9.0 scientific validation period I	06 - 29-Mar-2000
OLP 9.0 software and calibration file upgrades delivery (2)	29-Mar-2000
OLP 9.0 scientific validation period II	17-Apr - 05-May-2000
OLP 9.0 software and calibration file upgrades final delivery (3)	05-May-2000
Release of OLP 9.0 for On-the-fly re-processing	12-May-2000
Version 1 of ISOPHOT OLP 9.0 Scientific Validation Report	22-May-2000
Version 4.0 of ISOPHOT Calibration Accuracies (adapted to OLP 9)	June 2000

- **Impact on photometric results by a limited accuracy of the reset interval correction**
  This item will be investigated in more detail in the extension of the error propagation document [3].

- **FCS aperture correction (ISOPHOT-P)**
  This item requires a finalisation of the signal linearisation correction. It may be restricted to a correction of the 180 arcsec aperture with regard to the standard aperture in the respective filter in order to properly calibrate wide beam measurements on extended sources.

- **FCS straylight corrections for long wavelength detectors**
  This issue will be re-analysed, in particular for C200, to assess the fraction of sky background to the total heated FCS signal which would introduce a zero point offset into the FCS calibration.

- **Relative flux correction for multi-aperture measurements (ISOPHOT-P)**
  This correction accounts for non-flat beam profiles of the ISOPHOT-P apertures which are not concentric relative to each other, either. An absolute calibration of the multi-aperture sequence depends on a successful calibration of the FCS in non-standard apertures.

- **Non-linear drift removal in PHT-P nodding sequences**
  This item requires a finalisation of the signal linearisation correction. The timely evolution of the sky background signal level can then be used to fit a non-linear baseline.

- **Correction for systematic flat-field residuals**
  Dependent on the redundancy achieved by the mapping parameters (raster step size)

extra correction factors for systematic flatfield residuals can be derived from a statistical correlation method of surface brightness calibrated maps for a certain dynamic range in brightness or from flat sky background areas.

- **Non-linear drift correction in maps**
  Median filtering presents a method, which is however dependent on the background structure and may fail for an automatic processing. An extra map product with drift correction switched on may be provided.

- **Transient correction**
  A simple automatic algorithm, currently used for the special observational data base to establish the FCS calibration, may be applied. The amount of correction is limited in order to exclude excessive corrections by failed fits. This transient correction could be switched on, in case the currently implemented Man drift recognition algorithm indicated a non-stable measurement.

- **PHT32 calibration**
  This is a certain aspect of transient correction due to the fast chopper sweeps. Whether the methods developed for chopped photometry correction or a full transient modelling of the flux history will give satisfying photometry with this mode is still completely open.

Most of these issues are quite complex calibration programmes. They need detailed assessment and feasibility studies before a certain correction can eventually be implemented into the OLP. Therefore, no warranty can be given that all the items listed above will be finally available in OLP 10, which is the version foreseen to establish the ISO legacy archive. Another factor is the manpower available in all data centres working on ISOPHOT calibration issues.

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

[6] U. Klaas, P. Ábrahám, M. Haas, U. Herbstmeier, and R.J. Laureijs, "General ISOPHOT Observing Strategies for Faint Sources", SAI/97-013/Wb, Version 1.3, 28-February-1997

[7] P. Ábrahám, U. Klaas, M. Haas, U. Herbstmeier, M. Linden, and D. Lemke, "Detection Limit and Observing Strategy for Very Faint Point Sources: Test Observations with P3, C100, and C200", Version 2.0, PHT/MPIA Calibration Report, 29-April-1997

[8] T. Müller & J.S.V. Lagerros, "Asteroids as far-infrared photometric standards for ISOPHOT", 1998, A&A 338, 340

[9] U. Herbstmeier, P. Abraham, D. Lemke, R.J. Laureijs, U. Klaas, K. Mattila, Ch. Leinert, Ch. Surace, M. Kunkel, "Small-scale structures in the far-infrared background", 1998, A&A 332, 739

[10] C. Gabriel, M. Haas, I. Heinrichsen, and W.-M. Tai, "The ISOPHOT Interactive Analysis - PIA User's Manual", 1999 (for PIA V8.1)